# Foreword from the Superintendent

Poudre School District is committed to being a responsible steward of our natural resources and believes that public education should provide leadership in developing an ethic of sustainability in all of its practices. In Poudre School District, we have both Energy Conservation and Waste Management policies that espouse these values, making environmental stewardship an integral part of the physical plant operation. The purpose of the Sustainable Design Guidelines is to provide direction for applying these policies to the construction of new facilities and the renovation of existing schools.

As stewards of the natural environment, Poudre School District challenges the design community to help us build better schools. We believe that by working together in an integrated approach, we can build higher performance schools that provide a superior learning environment, while reducing life cycle costs through conservation of energy and natural resources.

We recognize that sustainable design may require a fundamental shift from certain aspects of conventional design and construction. However, we stand committed to sustainable design and are confident it will yield positive outcomes for our students and the community. Poudre School District is excited about this new direction. We look forward to working with you to achieve our goals of designing, building, and learning from sustainable schools.

Sincerely,

______________________________
Name, Superintendent of Schools

# Acknowledgements

The Sustainable Design Guidelines were written by Judy Dorsey and Clare L'Esperance of The Brendle Group, Inc., with word processing provided by Patty Burger. The authors acknowledge several people who contributed to this document. Foremost are the members of the Poudre School District Green Team.

Poudre School District has already demonstrated a commitment to sustainable design by establishing a multi-disciplinary Green Team in 1999. Led by the district architect, this team is represented by the major facilities departments, as well as other peripheral organizations. The team has been researching sustainable design practices and products, meeting regularly to discuss the feasibility of use within Poudre schools. These Sustainable Design Guidelines, particularly Sections 3.5, 3.6, and Appendix A, document the results of the Green Team's efforts.

The Green Team members include:

Mike Spearnak, District Architect
Bill Franzen, Facilities Director
Jeff Arnold, Facilities Planner
Stu Reeve, Energy and Technical Systems Manager
Pete Hall, Maintenance Supervisor
Jim Knauer, Head Carpenter
Jim Norgard, Master Electrician
Roger Smith, Technical Foreman
John Waldo, Head Plumber
Tom Weatherly, Head HVAC Technician
Alan Boatright, Custodial Supervisor
Donna Kramer, Custodial Supervisor
Frank Rayder, Outdoor Services Supervisor
Jerry Garretson, Landscape Foreman
Ellyn Dickmann, Security and School Operations Director
Norm Bastian, Security Manager
John Holcombe, Safety/Environmental Coordinator
Chris Rock, Food Fest Supervisor
Tracy Hoffman, Capital Funds Accountant
Gary Schroeder, Energy Services Engineer (City of Ft. Collins Utilities)

Outside reviewers, representing local expertise in sustainable design, provided additional comments and insights into the guidelines. The Brendle Group, Inc. recognizes and thanks the following reviewers for their contributions to this document:

Brian Dunbar, Director, Institute for the Built Environment at Colorado State University

Doug Swartz, Energy Services Engineer, City of Fort Collins Utilities

Jamey Evans, Green Buildings Specialist, U.S. Department of Energy, Denver Regional Office

This document contains several case studies. The authors wish to thank the following individuals for discussing their successes with us and sharing results in these sustainable design guidelines.

Susy Ellison, Yampah Mountain High School, Glenwood Springs, Colorado, "Strawbale Classroom".

Wyndol Fry, McKinney ISD, "Roy Lee Walker Sustainable Elementary School".

Scott Milder, SHW Group, "Roy Lee Walker Sustainable Elementary School".

Shara Pool, EDAW, Inc., Fort Collins, Colorado, "Gateway Science School".

Finally, two workshops co-sponsored by City of Fort Collins Utilities and Poudre School District were instrumental in the development of these guidelines. The following speakers are recognized for sharing their knowledge and expertise:

Sustainable Design: An Integrated Approach, March 14, 2000
Greg Franta, Ensar Group, Boulder, Colorado
Herb Schaal, EDAW, Inc., Fort Collins, Colorado
Kevin McBride, City of Fort Collins Utilities
Jack Wolpert, E-Cube Inc., Boulder, Colorado

Daylighting Goes Mainstream: How to Daylight Every School, April 5-6, 2000
Steve Ternoey, LightForms
Paul Hutton, Hutton Ford Architects

# How to Use This Guide

Rather than prescribing what is required for Poudre School District (PSD) facilities, these guidelines present the desired performance outcomes from employing sustainable design, and suggested approaches for attaining them. Many of the sustainable design strategies described in these guidelines require further analysis to determine feasibility on a project by project basis. The guidelines are therefore meant to illustrate sustainable design strategies and concepts, providing a starting point for further research.

This guide summarizes the product and technology research conducted by the Green Team (see Acknowledgements for a description of Green Team), describing those that will likely be most useful and relevant to school buildings. It also provides numerous case studies and references to further investigate opportunities on specific projects. It should be noted that the case studies are intended for illustrative purposes only; they do not necessarily reflect products or technologies intended for use by Poudre School District.

There are many purposes for which the Sustainable Design Guidelines may be used. The following table organizes the contents of the Sustainable Design Guidelines in terms of these purposes:

| To Read About… | Go To… |
|---|---|
| The basic tenets of sustainable design. | Chapter 1 |
| Poudre School District's philosophy regarding sustainable design. | Chapter 2 |
| Strategies for how PSD will integrate sustainable design into procurement and project management practices. | Chapter 2 |
| Eleven key features of sustainable schools. | Chapter 3 |
| Case studies: successful sustainable features in school design and renovation. | Throughout the text in call out boxes |
| Green Team's sustainable design research results. | Sections 3.5, 3.6, and Appendix A |
| Resources available to help with designing sustainable schools. | Chapter 4 |

The Sustainable Design Guidelines provide the framework for how Poudre School District will apply sustainability to the construction of all new schools, as well as the renovation of existing structures. Specific requirements and approaches will be further defined on a project by project basis through the Request for Qualifications (RFQ), Request for Proposals (RFP), project specifications, and contract documents.

The guidelines will be updated periodically. Consultants, suppliers, or contractors who wish to comment may direct their remarks in writing to **Poudre School District, Construction, Design & Planning Services, 2407 LaPorte Avenue, Fort Collins, Colorado 80521-2297**.

# Contents

# 1.0 Introduction to Sustainable Schools

The word "sustainable" means meeting the needs of the present without jeopardizing the ability of future generations to meet their own needs.[1] Sustainable Design is the systematic consideration, during design, of a project's life cycle impact on environmental and energy resources. By definition, the overarching tenet of sustainable design is to use resources efficiently and within their renewable limits.[2] While responsible stewardship of the environment is important, sustainable design also provides a better physical environment for students and staff, at lower life cycle costs for the school district.

***"…sustainable design provides a better physical environment for students and staff, at lower life cycle costs for the school district.."***

Goals for a typical sustainable building include:
(adapted from footnote 2)

1) Increase energy and water conservation and efficiency
2) Increase use of renewable energy resources
3) Reduce or eliminate toxic and hazardous substances in facilities, processes, and their surrounding environment
4) Improve indoor air quality and interior and exterior environments leading to increased human productivity and performance and better human health
5) Use resources and material efficiently
6) Select materials and products that would minimize safety hazard and life cycle environmental impact (e.g., local materials and lowest "embodied energy" materials
7) Increase use of material and products with recycled content and environmentally preferred products
8) Recycle and salvage construction waste and building material during construction and demolition
9) Generate less harmful products during construction, operation, and decommissioning/demolition
10) Implement maintenance and operational practices that reduce or eliminate harmful effects on people and the natural environment
11) Reuse existing infrastructure, locate facilities near public transportation, and consider redevelopment of contaminated properties
12) Consider off-site impacts such as storm water discharge rates and water quality

### *A Pressing Concern*

Every new structure that is constructed without sustainable principles is a lost opportunity for the lifetime of that building. The lost opportunity is staggering considering that design and construction are estimated to account for only 20 percent of a building's total life cycle cost, yet decisions are made during design which commit up to 80 percent of the building's life cycle cost. In other words, design decisions determine how a building will perform throughout its

[1] 1987. *Our Common Future***.** Report by the World Commission on Environment and Development (Bruntland Commission).
[2] Peterson, K.L, and Dorsey, J.A, "Roadmap for Integrating Sustainable Design into Site-Level Operations", Pacific Northwest National Laboratory (PNNL), 2000.

operational life from a resource consumption and waste generation standpoint, substantially impacting annual operating costs.

Since the motivating premise of sustainability is to meet the needs of the present without jeopardizing the ability of future generations to meet their own needs, what better way to ensure sustainability than to educate the next generation about their role in a sustainable future? Furthermore, Colorado school districts are experiencing first hand the effects of growth, requiring them to build new schools to accommodate increasing enrollments. For these reasons, schools are an ideal application for sustainable design in Colorado.

### *Eco-Education*

Although schools are an ideal application for sustainable design, the full benefits are lost if the building itself is not used to help teach students about sustainability and their role in a sustainable future. In science, for example, students are expected to *know and understand interrelationships between science, technology, and human activity and how they can affect the world*. Despite this fact, schools and classrooms continue to be designed and built that are inadequate vehicles for teaching these principles. Spaces for learning can be embedded with subject matter from native materials, to daylighting, to visually accessible building systems, to dynamic technologies. School buildings can provide for practical applications of science, math, and art principles.

***"…buildings and landscape reflect a hidden curriculum that powerfully influences the learning process."***

***Prof. David Orr***
***Oberlin College***

For example, according to Professor David Orr, Director of Environmental Studies at Oberlin College, "Their [school buildings] design is thought to have little or nothing to do with the process of learning or the quality of scholarship that occurs in a particular place, when in fact buildings and landscape reflect a hidden curriculum that powerfully influences the learning process. The curriculum embedded in any building instructs as fully and as effectively as any course taught in it."[3] For these reasons, sustainable schools should give consideration to "eco-education"[4], incorporating the environmentally sound building into the educational program (see Section 3.11).

### *Diverse Benefits*

Beyond the opportunity for eco-education, other important benefits of sustainable design in schools are improved indoor air quality and cost savings from decreased energy consumption and other conservation practices. Ninety percent of our time is spent inside buildings and only ten percent of our time is spent outdoors. The built environment should and can be as healthy as the outdoors when sustainable design principals are used.

Furthermore, over a thirty-year period for a commercial building, it is estimated that only two percent of life cycle costs are spent on construction; eight percent

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[3] Orr, David W. "Architecture as Pedagogy". Orion *Afield*. Spring 1999.
[4] SHW Concepts, Fall 1998. *www.shwgroup.com*

***Students learn more, perform better, and attend more often, when they are schooled in a sustainable building.***

on building energy and maintenance; and ninety-two percent on salaries.[5] Therefore, one of the biggest cost savings from sustainable design stems from improved worker productivity. Similarly, perhaps the most significant benefit of sustainable design for Poudre School District is that students learn more, perform better, and attend more often when they are schooled in a sustainable building. Students simply do better when their school is full of daylight, fresh air, and comfortable temperatures.

***Case Study: The Roy Lee Walker Sustainable Elementary School, McKinney, Texas***


In fall 2000, McKinney ISD will open Texas' first state-funded sustainable school, made possible by a grant from the General Services Commission/State Energy Conservation Office. Sustainable design is, essentially, environmentally sensitive architecture — the ability to meet today's needs without compromising the resources available to future generations. "We are beginning the bid process and plan to break ground by April," said Mike Elmore, Vice President with SHW Group, McKinney's architectural firm. "Opening in 2000 is perfect because the school's design has evolved into what we believe will define the 21st Century school." The school's sustainable design includes: **Daylighting** — Light monitors (depicted in the illustration) will scoop the sunlight in, bounce it off light baffles, and provide evenly distributed, non-glaring daylight into learning spaces. **Rainwater Collection** — Rainwater is channeled through special gutters to four cisterns, where it supplies water for campus irrigation. **Wind Energy** — A 30-foot windmill converts wind power into school power. This feature is a teaching tool; the energy harvested will supply power to pump water from the cisterns. **Weather Center** — A computer station weather center is located in the school's science classroom and includes a periscope that extends straight through the roof to monitor campus weather. **Outdoor Amphitheater** — An outdoor teaching space allows students to experience the school's natural habitat. **Materials Selection** — Wherever possible, materials selected are recycled and/or manufactured or quarried in Texas. **Sustainable Stations** — Touch-screen computer stations will provide detailed information about the school's unique design. **Sundial** — A large sundial will help students learn to identify winter and summer solstices, the shortest and longest days of the year, and read time.

For more on the McKinney ISD project or sustainable design, see the fall 1998 issue of Concepts at *www.shwgroup.com*.© Copyright 1999 SHW Group Inc. All rights reserved. Illustration intended for teaching purposes only. Drawing by SHW Group.
***Disclaimer: This and all other case studies within these guidelines are intended for illustrative purposes only. They do not necessarily reflect in whole, or in part, the products or technologies intended for use, by Poudre School District.***

[5] Sustainable Building Technical Manual. *www.sustainable.doe.gov*

# 2.0 The Sustainable Design Process: Business is Not as Usual in Poudre School District

## 2.1 Overview of PSD Sustainable Design Philosophy

Poudre School District believes that sustainable design offers an opportunity for superior learning environments *and* long-term cost savings in building operations and maintenance. These are not competing interests, but goals that can be achieved simultaneously through schools that:

- enhance student performance and attendance
- teach principles of sustainable design
- harmonize with the natural landscape
- provide higher quality lighting
- consume less energy
- conserve materials and natural resources
- enhance indoor environmental quality, and
- safeguard water[6]

***PSD's philosophy is to utilize sustainable design as a lever for realizing a superior learning environment characterized by long-term cost savings.***

To achieve this, sustainable design may require a fundamental shift from certain aspects of conventional design and construction. The initial shift to sustainable design may take more time and cost more money for design services, but not necessarily increased construction costs, and certainly lower building life cycle costs. Poudre School District's philosophy, therefore, is to utilize sustainable design as a lever for realizing a superior learning environment characterized by long-term cost savings. These are cost savings that can be reinvested into education, rather than building operations and maintenance.

To balance the short-term costs and risks of sustainable design with its long-term benefits, PSD intends to:

- build schools that are state-of-the-art without being experimental,
- utilize exemplary buildings as precedent, rather than reinventing previous work in sustainable design,
- share risk and rewards by collaborating with other benefactors of sustainable schools such as the City of Fort Collins, State, and Federal agencies, and
- use performance agreements, where appropriate, to further share the risks and rewards with contractors.

[6] From "Sustainable Design: An Integrated Approach" workshop, March 14, 2000. Jointly sponsored by Poudre School District and City of Fort Collins Utilities.

In implementing this philosophy, PSD will advocate an integrated, multi-disciplinary, design approach with review and input by all stakeholders. Only through an integrated approach will PSD realize significant energy reductions and resource conservation for the whole building, rather than incremental improvements in individual building systems. For example, efficient lights and windows can result in smaller and therefore less expensive mechanical systems being installed.

Keeping with the desire to use resources wisely, PSD's philosophy is to design schools for durability, functional flexibility, maintainability, and ease of deconstruction/recycling after its useful life.

## 2.2 New Approaches to Project Management

A shift in design philosophy warrants a corresponding shift in project management methods. Poudre School District intends to implement its sustainable design philosophy by implementing some or all of the following project management steps[7]:

1. Clearly define sustainable design goals in requests for qualifications (RFQs), requests for proposals (RFPs), and bid review criteria (see Section 2.3).

2. Select team members who are experienced with or interested in utilizing sustainable design strategies.

3. Establish contracts that encourage collaboration and excellence in sustainable design and construction practices (see Section 2.3).

4. As soon as the project is established, the team will review similar projects with exemplary results for resources and lessons learned. Note: numerous case studies have been researched and included throughout these guidelines in easy to read call out boxes from the main text. Additional case studies can be found in the resources described in Chapter 4.

5. Conduct one to two design charrettes (at conceptual design and/or schematic design) with stakeholders and specialists (see Section 2.4).

6. Establish an electronic conference site. Post goals and results of charrettes. Invite feedback and require consultants to evaluate/monitor response.

7. Set standards and measurable goals for sustainable building performance. For example, lighting power density in watts per square foot, energy consumption in BTU's per square foot, percent of material that will be reused, recycled, recycled content, etc.

8. Develop an energy model that evolves with and informs the design.

[7] Adapted from "Ten Steps to Sustainable Design Management" by Berkebile, Nelson, Immenschuh, McDowell Architects, Kansas City, MO, INFO@BNIM.COM.

9. Look for design opportunities that provide multiple benefits and cost tradeoffs.

10. Evaluate costs and conduct value engineering only from a whole building perspective.

11. Expand the timeline for normal design development and construction phases, allowing time to evaluate new systems and products, and to perform building simulations.

12. Establish instrumentation for monitoring and evaluating building performance, including commissioning and post-occupancy evaluation (see Section 3.10).

13. Perform post-occupancy inspection (one year minimum), with recommendations as appropriate for operational improvements.

## 2.3 New Approaches to Procurement

***Contractor Experience and Expertise in Sustainable Design***

***PSD will seek out demonstrated contractor experience in applying sustainability concepts and principles to the design of schools through an integrated design approach.***

To ensure implementation of its sustainable design philosophy, one approach Poudre School District intends to take is to select design and related professional services on the basis of knowledge and demonstrated experience in applying sustainability concepts and principles to the design of schools through an integrated design approach.[8]

Demonstration of this knowledge will be specified in both Request for Qualifications (RFQs) and Request for Proposals (RFPs). Specifically, design teams will be asked to demonstrate:

? Expertise with environmentally responsible or sustainable school design.

? Specific expertise in applying "Integrated Design" methodologies.

? Experience with projects that use less heating and cooling energy than conventional standards.

? Experience with projects that use less electrical energy and less energy for lighting than industry standards.

? Experience with projects with LEED™ or other green building ratings.

? Experience with projects that have specifically addressed ensuring good indoor air quality through use of less toxic materials, integrated pest management, etc.

[8] Adapted from the Naval Facilities Engineering Command Planning and Design Policy Statement - 98-03.

- Experience with projects demonstrating site planning that sustains and enhances the natural environment by: maximizing solar energy potential and use of natural light; maximizing the potential for natural ventilation; and minimizing off-site storm water runoff.

- Experience writing specifications requiring waste management and recycling plans for construction and demolition.

- Experience with life-cycle analysis techniques to select building materials that minimize environmental impacts.

- Client references for previous sustainable design work.

If the sustainable design expertise resides with a subcontractor rather than prime contractor, priority will be given to teams that have had success working together on prior sustainable design projects. Priority will be given to submittals containing at least one sample of a sustainable project previously designed by the firm, including an explanation of:

- Increased energy conservation and efficiency

- Increased use of renewable energy resources

- Application of daylighting strategies

- Reduction or elimination of toxic and harmful substances

- Efficiency in resource and materials utilization

- Selection of materials based on life-cycle environmental impacts

- Recycling of construction waste and building materials after demolition

- Metered performance and post occupancy evaluation data

### *Reviewing and Scoring Proposals for Sustainability Issues*

Poudre School District further intends to include sustainability in the criteria for reviewing and scoring proposals received from design firms. This may entail assigning points to specific sustainable features (see APEL case study next page)[9] or it may entail use of the LEED™ credit system (see Section 2.5). Applicants may be required to estimate the number of LEED™ credits the completed project would qualify for, and to document how the points would be obtained.

[9] Peterson, K.L, and Dorsey, J.A, "Roadmap for Integrating Sustainable Design into Site-Level Operations", Pacific Northwest National Laboratory (PNNL), 2000.

In keeping with the sustainable philosophy, Poudre School District desires and encourages that proposals be submitted on recycled paper and printed on both sides. While the appearance of proposals and professional presentation is important, the choice of proposal materials (paper, inks, binding materials, etc.) should appropriately reflect the teams understanding of, and commitment to, the sustainable principles sought in the project itself.

***Case Study: The Applied Process Engineering Laboratory (APEL), Richland, Washington***

This project allocated ten points towards sustainable design, out of a possible 100 points, for evaluating proposals received for a design/build contract. Although the major emphasis was on the quantity and quality of work delivered for a fixed price, sustainability (10 percent of the possible points) proved to be a deciding factor in choosing the contractor. The ten sustainable points were allocated as follows:

| Sustainable Design Item | Award Points |
|---|---|
| Integration of Pollution Prevention into Design | 3 |
| HVAC Energy Conservation | 3 |
| Electrical Energy Conservation | 1 |
| Building Envelope Energy Conservation | 1 |
| Use of Recycled Content Materials | 1 |
| Spill Protection for Floors | 1 |

### *Alternative Contract Mechanisms*

Once a design firm is selected, Poudre School District may employ alternative contract mechanisms such as Performance Based Fees (PBF), in order to provide its design professionals with an incentive to design for sustainability and to share the risks and rewards of doing so.

***Energy efficiency is a goal all designers strive for, but achieving exceptional efficiency often requires an investment of more design time.***

Energy efficiency is a goal all designers strive for, but achieving exceptional efficiency often requires an investment of more design time. However, conventional payment methods provide no extra award for the extra effort, nor do the designers receive any of the savings their extra work creates during building operations. Typically architects and engineers get paid less per hour for putting in more time.[10]

Under a PBF concept, a portion of the design fee is contingent upon meeting an energy performance target established in the initial agreement. This requires developing a base case and running computer simulations comparing the base case to the energy efficient building design (the base case might be chosen based on local code or based on the most recent school design and their metered energy use). If the building performs no better than the base, the A/E team receives no additional fee, despite having incurred the cost of performing the additional services. If the building performs at a level between the target and the base, the

[10] Hubbard, Gunnar and Eley, Charles, "Green Fees: Getting Paid for Getting it Right - Performance Based Fee Contracts for New Construction", *www.rmi.org/gds/pbf/index.html*.

additional fee is prorated. If the building performs better than the target, the A/E compensation is proportionately greater than the value of the additional services.

***Case Study: North Clackamas High School, Performance Based Fee (see footnote 10)***

This public high school, located in Portland, Oregon, has a lot to benefit from a PBF contract. As a public project, the design must be agreed upon by bond approval. The design life of the building is 50-100 years. The greater the savings that can be achieved on an annual basis, the better the school will be for the community. The client, the North Clackamas School District, saw PBF contracting as a way to guarantee savings by reducing energy bills as much as possible.

The design for this 250,000 square foot project has extensive daylighting and stack vents for passive cooling. The cooling systems are completely eliminated from the classrooms, and are downsized and localized for the administration areas, the gym, and the auditorium. Radiant panels are being considered for heating, and light shelves on the south classrooms are designed to take advantage of daylighting.

VisualDOE modeling and comparisons against recently constructed high schools indicate that the proposed design will save $50,000 per year over the agreed-upon base performance level (Oregon Energy Code). The team estimates it will cost an additional $89,000 in design costs for these features. Costs for commissioning, measurement, and evaluation will push the additional cost to perhaps as high as $150,000. The simple payback period is therefore no greater than 3 years.

Under the PBF contract, the design team negotiated to be paid $50,000 for the first year and $39,000 for the second year in order to recoup the added $89,000 in design costs.

## 2.4 Sustainable Design Charrettes

A "Sustainable Design Charrette" is a process advocated by the American Institute of Architects (AIA) in which a multi-disciplinary team works together to envision alternative design solutions for a building program with an emphasis upon long-term economic, social and environmental sustainability.[11]

The term “charrette” is adopted from the practice of *Ecole des Beaux Arts* students in nineteenth century Paris. Charrette, in its modern day adaptation, refers to an intensive design workshop involving people from various disciplines working together under compressed deadlines. The American Institute of Architects Committee on the Environment has recently endorsed the Sustainable Design Charrette process as a preferred alternative to the traditional linear process of designing and constructing built environments.

[11] Watson, Donald, FAIA. 1996. American Institute of Architects, Committee on the Environment, Environmental Design Charrette Workbook, ISBN #1-879304-86-04.

Typically, a Sustainable Design Charrette is a workshop held in a two-to-three-day period. Poudre School District will consider holding one to two charrettes during the design phases of a new school (during conceptual and/or schematic design).

The charrette participants would operate as an "expanded design team", providing expertise and input to the core design team in an integrated fashion. The participants may include PSD project management, facilities staff and educators, contracted design and professional service firms, as well as outside expertise and other project stakeholders, such as the Fort Collins Utilities, Colorado State University design and engineering faculty, and U.S. Department of Energy buildings specialists.

## 2.5 LEED™ Certification and the Role of Standards

Building standards and certifications sought will be determined on a project by project basis. However, Poudre School District will use the Leadership in Energy and Environmental Design (LEED™) standard as a benchmark for comparing different design proposals and as a resource for investigating opportunities in sustainable design.

The LEED™ Green Building™ Rating System is a program of the U.S. Green Building Council. It is a voluntary, market-driven building rating system that evaluates energy and environmental performance from a "whole building" perspective over a building's life cycle. LEED™ is intended to define what constitutes a "green building".

LEED™ is a self-certifying system for rating new and existing commercial, institutional, and high-rise residential buildings. It is a feature-oriented system where credits are awarded for satisfying different criteria. In addition, there are prerequisites that every building must meet in order to be certified. The LEED™ system is currently being revised and updated to version 2.0, but retains much of the core component of version 1.0, of which the prerequisites and credits are summarized in the following table. For more information, a complete description of the program can be downloaded from *www.usgbc.org*.

**LEED™ Scorecard**

**11 Points: Planning Sustainable Sites**

- ✍ Credit 1 - Landscaping for Erosion Control
- ✍ Credit 2 - Reduce Heat Islands
- ✍ Credit 3 - Infill Development
- ✍ Credit 4 - Reduce Habitat Disturbance
- ✍ Credit 5 - Site Preservation/Restoration
- ✍ Credit 6 - Efficient Building Location
- ✍ Credit 7 - Alternative Transit Facilities
- ✍ Bonus Credit 1 - Alternative Fueling Facilities
- ✍ Bonus Credit 2 - Brownfield Development

**11 Points: Improving Energy Efficiency**

- ✍ Prerequisite 1 - Building Commissioning
- ✍ Prerequisite 2 - Energy Efficiency
- ✍ Credit 1 - Energy Efficiency (1 to 5)
- ✍ Credit 2 - Natural Ventilation, Heating, & Cooling
- ✍ Credit 3 - Waste Heat Recovery System
- ✍ Credit 4 - Renewable/Alternative Energy (1 to 3)
- ✍ Bonus Credit 5 - Measurement and Verification

**12 Points: Conserving Materials and Resources**

- ✍ Prerequisite 1 - Elimination of CFCs
- ✍ Prerequisite 2 - Storage/Collection of Recyclables
- ✍ Credit 1 - Existing Building Rehab. (1 or 2)
- ✍ Credit 2 - Resource Reuse (1 or 2)
- ✍ Credit 3 - Recycled Content (1 or 2)
- ✍ Credit 4 - Construction Waste Management (1 or 2)
- ✍ Credit 5 - Local Materials
- ✍ Credit 6 - Elimination of CFCs/Halons (1 or 2)
- ✍ Credit 7 - Occupant Recycling

**7 Points: Enhancing Indoor Environmental Quality**

- ✍ Prerequisite 1 - Elimination of asbestos
- ✍ Prerequisite 2 - Indoor Air Quality
- ✍ Prerequisite 3 - Smoking Ban
- ✍ Prerequisite 4 - Thermal Comfort
- ✍ Credit 1 - IAQ Management Plan (1 or 2)
- ✍ Credit 2 - Low VOC Materials (1 or 2)
- ✍ Credit 3 - Permanent Air Monitoring
- ✍ Credit 4 - Chemical Storage Areas
- ✍ Credit 5 - Architectural Entryways

**8 Points: Safeguarding Water**

- ✍ Prerequisite 1 - Water Conservation
- ✍ Prerequisite 2 - Elimination of Lead
- ✍ Credit 1 - Water-Conserving Fixtures
- ✍ Credit 2 - Water Recovery System
- ✍ Credit 3 - Water Conserving Cooling Towers
- ✍ Credit 4 - Water-Efficient Landscaping
- ✍ Credit 5 - Surface Runoff Filtration
- ✍ Credit 6 - Surface Runoff Reduction
- ✍ Bonus Credit 1 - Biological Waste Treatment
- ✍ Bonus Credit 2 - Measurement and Verification

**1 Point: Improving the Design Process**

- ✍ Credit 1 - LEED™ Certified Designer

**50 Total Possible Points**

# 3.0 The Sustainable Design Product: Eleven Features of Sustainable Schools

While Chapter 2.0 focused on how sustainable design impacts the project management *process*, Chapter 3.0 now turns to the question of what physically will be different about the design *product.* That is, what features will characterize sustainable new schools, as well as renovations to existing schools.

The following eleven features collectively represent a comprehensive, sustainable school:

1) Sustainable site planning and landscape design
2) Use of renewable energy sources
3) High quality and energy efficient lighting
4) Energy efficient building shell
5) Energy efficient HVAC systems
6) Environmentally preferable building materials
7) Water conservation
8) Recycling and waste management
9) Construction waste reduction and recycling
10) Commissioning
11) Eco-education

Each of these features is developed in more detail in the remaining sections of this chapter. As noted earlier, these guidelines do not necessarily reflect requirements for new schools. Rather they illustrate possible features that need to be developed in further detail during the design phases of specific projects.

## 3.1 Site Planning and Landscape Design

Site planning is critical to the success of a sustainable building. Careful planning, building orientation, and landscaping can cut energy consumption levels and monthly utility expenses considerably. Analysis of the site should consider all existing features both natural and human made, to determine the inherent qualities that give a site its personality. A topographical analysis of existing features is advised. Emphasis should be placed on the site's relationship to the larger environment and its special values. This analysis includes natural, cultural, and aesthetic factors that affect it.[12] The site should also be viewed as a valuable resource for education, not just a building site.

[12] Rubenstein 1996. *A Guide to Site Planning and Landscape Construction*

At least eight features characterize a sustainable school site:[13]

1) Bio-diversity

2) Low input after establishment (e.g., water, mowing, labor, fertilizers, etc.)

3) Relates to and is connected to the area's natural systems

4) Uses green materials where possible (see Section 3.6)

5) Looks like it belongs in the bio-climatic region (automatically met if items 1-4 are true)

6) Visible from the indoors

7) Modulates heating and cooling of the building (e.g., wind buffers, shading)

8) Reinforces the health and welfare of the local community and economy and engages the community in its construction and use

In site planning for the built environment, the designer must be aware that any structure will inevitably, by virtue of its physical presence and functioning, affect not only the site's ecosystem but others elsewhere. The structure's possible influence on surrounding ecosystems must be included as part of the set of design considerations.[14] The well designed building site lets natural energy sources work for it, such as solar heating and natural cooling breezes.

Natural water features such as small streams or ponds are some of the most powerful elements in landscape design. They also contribute to lowering the temperature by cooling breezes, which may enter the building. When designing open spaces, pay particular attention to natural drainage patterns. They can act as a design determinant and can produce beautiful landscaping features that: serve as a wildlife habitat; reduce off-site water flow; are incorporated into the City's storm water quality criteria (by improving the quality of storm water runoff)[15]; supply water for landscaping; and cost substantially less to build and maintain than conventional storm drainage.[16]

In designing water features, consult the City of Fort Collins Stormwater Quality WaterSHED Program (Stormwater, Habitat, Education, Development). This program works with local elementary school science curriculum to provide outdoor educational opportunities. Their experiences working with school students should be consulted during site planning of future schools.

[13] Herb Schaal, EDAW, Inc. From "Sustainable Design: An Integrated Approach" workshop. March 14, 2000. Fort Collins, Colorado.
[14] Yeang 1995. *Designing with Nature*
[15] Urban Drainage and Flood Control District. Drainage Design Manual, Volume 3.
[16] Rocky Mountain Institute 1995.

***Case Study: Gateway Science School, St. Louis, Missouri***
Description and sketch provided by EDAW, Inc. Fort Collins, Colorado.

A 1998 court order directed that three new St. Louis magnet schools be constructed in the Math-Science Technology Cluster. Two of the schools are the Gateway Elementary with 574 students and the Gateway Middle with 690 students. EDAW provided complete design services for the 21-acre site and for a 2-acre secured courtyard. The courtyard serves as an outdoor laboratory representing several ecosystems (forest, prairie, pond and crags) and demonstrating various scientific principles. The overall plan is rich in both geometric and naturalistic metaphors, appropriate to the math and science curriculum.

A thread of naturalistic landscape runs through the entire site. It separates schools and use areas, and strongly organizes the design. More importantly, the ever-present natural area serves as a reminder that the earth's natural resources are the basis of all life and that the highest purpose of science is to find sustainable solutions to man's habitation of the planet.

Specific sustainable design and/or eco-education features employed in the site include:

? An "Isaac Newton" apple tree
? Site drainage goes to "Walden Pond", which self-cleans runoff to storm drains
? Fossils in the walkway with every 17 feet representing one million years of geologic time
? Animal tracks in the sidewalk in alphabetical order
? Built to scale solar system
? Hydraulics lab with a spiral flume, water wheel, and channeled stream
? Windmill
? Paving materials from rubberized recycled tires
? Community garden outside the courtyard
? Bridge pilons constructed from materials representing the economical minerals for the state of Missouri

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# 3.2 Renewable Energy Sources

Currently, 98 percent of Colorado's energy is produced from fossil fuels -- coal, oil, and natural gas.[17] Predictions vary widely, but fossil fuel supply is finite, and fossil fuel combustion produces air pollutants and contributes to global warming. In contrast, renewable energy sources are constantly replenished and don't have the environmental consequences associated with combustion. Renewable energy also provides an educational opportunity for students to understand the earth's natural processes and how to put them to work for humans. For these reasons, Poudre School District is interested in investigating the potential for using renewable energy sources in schools.

## 3.2.1 Using Solar Energy in Schools

The sun serves as a pollution-free source of energy for schools. The technologies to capture the sun's energy range from inexpensive options that can easily be incorporated into new buildings, such as daylighting (see Section 3.3.1), to more expensive options, such as photovoltaic systems.

***Passive solar heating*** relies on the design of the building to capture and hold the sun's heat. Passive solar often go hand-in-hand with daylighting, which uses natural sunlight to supplement or replace indoor electric light. A problem can be too much solar heat; solar gains must be controlled. Passive solar heating can be incorporated into new school designs at little or no cost.

***"A building should be like a tree, it should thrive on the sun's energy while enhancing its surroundings" WILLIAM McDONOUGH, ARCHITECT, 1993***

***Ventilation preheating*** is an inexpensive and efficient means of using solar energy to supplement space heating in a school. It requires a south-facing wall without windows. The system involves a black metal sheet heated by the sun mounted against the wall. The intake air for the ventilation system is drawn through holes in the metal sheet and heated. The systems are incorporated into new schools or added as a retrofit to existing schools.[18]

***Solar hot water systems*** use various "collector" technologies to collect sunlight for heating water. Although solar hot water systems have higher initial costs than other water-heating technologies, the energy savings will pay back the cost of the system.

***Solar photovoltaic systems*** generate electricity directly from the sun. They are currently a more expensive source of electricity than utility power. However, photovoltaic systems serve as a useful teaching aid and provide a true "hands-on" experience with solar energy. American Electric Power, for instance, has created

[17] "Colorado's Clean Energy Sources" pamphlet produced by the U.S. Department of Energy National Renewable Energy Laboratory, April 2000. Available from the Governor's Office of Energy Management and Conservation, 303-620-4292.
[18] see *www.eren.doe.gov/solarbuildings/tech-transpired_bib.html* and *www.buildinggreen.com products/solarwall.html*

a web site that displays the power generation from a photovoltaic system on Bluffsview Elementary School in Worthington, Ohio.[19]

***Case Study: PV Installed at 23 Colorado Public Schools***
From Schools Going Solar, Volume 2: A Guide to Schools Enjoying the Power of Solar Energy, Utility PhotoVoltaic Group (UPVG), *www.upvg.org*

*Students and teachers pose outside Powell Middle School, one of Colorado's Solar for Schools participants.*

Since November, 1998, photovoltaic systems were installed at 23 Colorado schools through a partnership between Public Service Company of Colorado (PSCo) and Altair Energy. The systems each produce two kilowatts of electricity and are tied to the utility grid system. Each will provide enough electricity to power one or two classrooms but "they are really meant as learning tools for the students," says Jennifer Harrison Lane, marketing director for Altair Energy. The partnership plans to install up to 40 school solar electric systems throughout Colorado by the end of 2000. In addition to electric generation systems, Altair Energy is installing a computerized performance-monitoring station as part of the package so that "real-time" electricity generation and weather data is available to each classroom. "Our company has trained the teachers about the system so they can then teach the kids," says Lane. The cost of each system and monitoring equipment cost $30,000 to $40,000. The PV installations are being funded through the PSCo's Renewable Energy Trust Solar for School Program, as well as by the Colorado Governor's Office of Energy Conservation and the UPVG/DOE TEAM-Up Program.

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### 3.2.2 Wind Energy for Schools

Wind energy employs a turbine for converting wind into either electric power or mechanical power, such as for pumping water. In schools, the primary interest is in electric power generation. Except in remote locations, this involves pumping power into the power grid. Poudre School District is interested in wind power both as a renewable energy source, and as an educational opportunity for students. No known precedent exists in Colorado, but the district would be

[19] *www.aep.com/environment/solar/graphs/index.html*.

willing to consider wind energy if a compelling engineering case were developed by the design team.

Iowa provides a good example of the possibilities of wind energy: four school districts have installed wind turbines and are reaping large energy savings. Forest City Community School District and Akron-Westfield Community School District (CSD) are Iowa's two latest school districts to adopt wind power for their energy needs. Each district installed a 600 kW wind turbine that began generating power in January 1999. The turbine in Forest City will save the district more than $51,000 annually, and Akron-Westfield CSD will reap more than $63,000 in annual energy savings. The turbines were financed through the Department of Natural Resources' Energy Bank Program and the Iowa Energy Center's Alternative Energy Revolving Loan Fund.[20] Specifics on Iowa's first school district to own a wind turbine are provided in the case study at the end of this section.

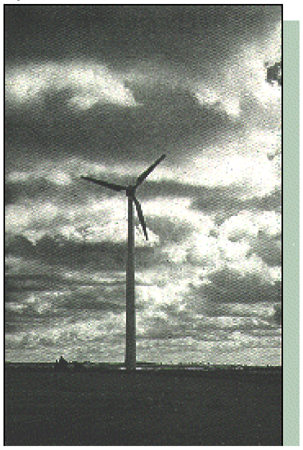
One of the first steps in assessing the possibility of using a wind turbine in a school district is to examine the wind resource. The Wind Resource Atlas of the United States, published by DOE's Pacific Northwest National Laboratory is a good place to start.[21] This atlas presents wind resource information in terms of wind "classes," numbered from 1 to 7. Wind classes of 3 or higher are considered viable for wind turbines. An initial review of the atlas indicates that wind classes in Poudre School District are class 3. The Fort Collins area probably has some "fair to good" locations for locating a small wind turbine, however the wind profile for any project is extremely site specific. Environmental and aesthetic issues may also be significant concerns for a project in an urban/suburban area.

Another consideration for wind turbine owners is the ability to sell excess power back to its utility, preferably at the same price they pay for electricity (as opposed to the much lower wholesale cost of power). This concept is often referred to as "net metering". The American Wind Energy Association's (AWEA) "Summary of Current State Net Metering Programs" indicates that Public Service Company will buy back energy produced by customers for all fuel types, including wind. The limit on system size is less than 10 kW but there is no limit on overall enrollment. Net excess generation is carried over month to month. This policy was enacted in 1994 by Public Service Company of Colorado through Advice Letter 1265, Decision C96-901.[22] There is a parallel generation clause in the City of Fort Collins Utilities rate structure, allowing for net metering.

[20] See *www.state.ia.us/government/dnr/energy/pubs/dem/ecase/ecase.htm* and *www.state.ia.us/government/dnr/energy/programs/ren/wind.htm.*
[21] *www.rredc.nrel.gov*
[22] *www.awea.org*

***Case Study: Wind Turbine at Spirit Lake Elementary School***
From the Iowa Energy Bureau Web-Site at *www.state.ia.us/government/dnr/energy/pubs/dem/ecase/ecase.htm.*

Spirit Lake Wind Turbine



The Spirit Lake School District received a lot of attention in July 1993 when it became only the second school district in the nation to own a wind turbine. "I've never done anything that's been so popular in the community," said Spirit Lake Superintendent Harold Overmann. "People wonder why we don't have more of these things."

***Ideal Location***

Spirit Lake's windy location in northwest Iowa made it an ideal location for a wind turbine. The 140-foot tall turbine produces electricity for the Spirit Lake elementary school. Since it began charging, the turbine has run "almost perfectly." The only problems with the turbine have occurred in extreme weather situations. During ice storms, ice has clung to the rotors, forcing it to shut down. The turbine also shuts off when winds exceed 56 mph. In both situations, a manual start-up is all that is required.

***Selling the Excess***

The turbine produces 324,000 kW of electricity annually, which amounts to $24,900. The elementary school, however, uses only $20,000 worth of electricity. Through an agreement signed with IES Utilities, the district sells its excess electricity to the utility company. The turbine cost $238,000 to install. A grant from the U.S. Department of Energy paid for half of the cost and the district acquired a loan from the Iowa Energy Bank Program to pay the other half. With the $25,000 yearly savings, the turbine will be completely paid for in less than five years. After that, the money saved can be directed into education. "We're using our non-instructional costs for instructional costs," said Overmann. "With the money we save we can fully equip a computer lab every year instead of paying for electricity."

***Helping the Environment***

Not only is the district helping itself, but it is also saving the environment. Using wind instead of coal in the school replaces 225 tons of coal and prevents 750,000 pounds of carbon dioxide emissions from polluting the air every year. "That part really goes unsaid. But we're proud that we are helping to solve the pollution problem," said Overmann.

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### 3.2.3 Geothermal Heating and Cooling Systems

Today, more than 500 schools in 38 states enjoy the benefits of geothermal heating and cooling systems, and the number is growing almost daily. More than one million students and almost 50,000 teachers already work and study in an environment heated and cooled by geothermal systems.[23] However, geothermal systems may not be a good option for schools of all sizes and locations. An

[23] Energy Smart Schools, *erendoe.gov/energysmartschools/elementary_geo.html*

engineering study is required to evaluate soils, water table, and other factors before this type of system can be selected.

***"Today, more than 500 schools in 38 states enjoy the benefits of geothermal heating and cooling systems, and the number is growing almost daily."***

### *How They Work*

Below the frost line, the earth maintains a relatively constant temperature that is warmer than surface temperatures during winter months, and cooler than surface temperatures during summer months. Geothermal heating and cooling systems take advantage of this temperature differential by pumping heat from or to the earth.

In most school installations, this requires one heat pump for every one or two classrooms. The earth connection is either a series of buried pipes (closed loop) or water wells (open loop), often buried beneath parking lots or playing fields.

### *Advantages of Geothermal Heating and Cooling Systems*

? Lower energy operating costs (up to 25 to 50 percent less than conventional systems)

? Potentially lower construction costs due to smaller mechanical spaces

? Classroom comfort and user satisfaction from individually controlled units

? Potentially less indoor air pollutants from no combustion of fossil fuels

? Typically more quiet than traditional systems

### *Disadvantages of Geothermal Heating and Cooling Systems*

The Poudre School District Green Team has investigated geothermal systems, including a visit to an installed system at an elementary school in Lincoln, Nebraska. Although the district is committed to the use of renewable energy and energy conservation where practical, there are several concerns that would need to be addressed during project design in order for a geothermal system to be approved.

The disadvantages and concerns are:

? Multiple compressors and fans. One per classroom would mean up to 35 systems to maintain.

? Larger rooms may require backup heating, so the advantages of geothermal are diluted.

? Concerns with reliability and performance of wellfields.

? Overall concerns with maintenance requirements for a complex, new system.

? Concerns with indoor air quality if air filtering is inadequate and/or if fresh air into the building is limited.

***Case Study: Onamia Elementary School, Onamia, Minnesota (www.geoexchange.org)***

***Benefits and Drawbacks of Geothermal Heating and Cooling Systems***

At Onamia Elementary, where temperatures can drop to 40 or 50 degrees below zero at times, more than 50 heat pumps - one for every room in the 78,000 square-foot school - are connected to a field of 560 shallow boreholes with more than 10 miles of plastic pipe. Each borehole is about 5 inches wide and 50 feet deep. Pipes carrying a solution of water and antifreeze, draw heat from the surrounding ground and carry it into the school, where the heat pumps extract the warmth. Because the boreholes are so shallow (they're usually hundreds of feet deep, but they had bedrock at about 50 feet), there had to be a lot of them. This translated into a large borefield, covering more than one acre.

The cost of the system was about $50,000 more than the estimated cost of a conventional heating system plus an air conditioning system. The energy savings comes in part from a 10-year flat rate of $0.049/kWh, and no demand charge, granted to all schools using ground source heat pumps by the local electrical utility.

For educational purposes (see Section 3.11), school officials set aside an area in the mechanical room where a lighted display of the system has been mounted on one wall. A heat pump is also on view.

After an initial break-in period in which a few problems surfaced, the system works well, and is reported to be low maintenance. Filters are changed out once a month when classes aren't meeting because the heat pumps are located in the ceilings.

Contact: Jim Nelson, Owner Representative, or Dick Seemers, Building Operator. Both are at: Onamia Elementary School, (612) 532-4174.

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# 3.3 High Quality, Energy-Efficient Lighting

Lighting is a critical aspect for both a high-quality learning environment and an environmentally sustainable building. There are numerous opportunities to improve the quality of light, while significantly reducing the energy used by lighting. Lighting approaches should rely primarily on well-designed daylighting systems, complemented as needed by energy-efficient electric lighting systems. For both daylighting and electric lighting, the design should begin by carefully assessing the tasks to be performed. Controls may be needed to provide different lighting for different tasks in the same space. Daylighting and electric lighting should be designed only in the context of a whole-building design approach, starting with decisions on orientation and shape of the building.

## 3.3.1 Daylighting

Daylighting is defined as the use of natural light for illumination. Well-designed daylighting provides a superior quality of light, contributes to productivity, reduces energy costs, and improves the health of the occupants. Daylighting is more than simply installing a few skylights, it must be designed within the context of a whole building approach. In this regard, it can be an organizing principle for design. Daylighting involves consideration of heat gain, glare, variations in light availability, and sunlight penetration into a building. A successful design must address details such as shading devices, aperture size and spacing, glazing materials, and surface reflectance characteristics.[24] In large measure, the art and science of daylighting is not so much how to provide enough daylight, as how to do so without undesirable effects such as excessive heat gain, brightness and glare. Daylighting can also contribute to "transparency", increasing the connection between occupants and the outdoor environment.

***Benefits of Daylighting in Schools***

In 1992, an Alberta Department of Education, Canada study found that students enrolled in schools where daylighting was the principal source of internal light had the following advantages:

? Increased attendance by 3.5 days a year,

? Grew an average of one centimeter more than their peers enrolled in schools operating under electronic light,

[24] 1995 *Daylighting Performance and Design* Gregg D. Ander, AIA. International Thompson Publishing

? Better scholastic performance resulting from more positive moods induced by natural light,

? Increased concentration levels and significant reductions in library noise; and, surprisingly,

? One-ninth the rate of tooth decay.

Daylighting benefits have also been measured in Poudre School District. A 1999 study found that PSD students show a 7 percent improvement in test scores in those classrooms with the most daylighting, and a 14 to 18 percent improvement for those students in the classrooms with the largest window areas.[25]

### *Common Pitfalls*

Daylighting is not easy to do well. To be successful, daylighting needs to use a systems approach to design. There are many examples of buildings where good intentions, but limited expertise or lack of communication, resulted in less than desirable outcomes. Common pitfalls to avoid are:[26]

? Add-on approaches: Attempts to "add" daylighting to a building that is already largely designed are usually not successful – economically, aesthetically, or functionally.

? Too much direct sun: Direct sun is unpleasant in many settings, due to excessive light levels, glare, and heat.

? Too much light: Even when direct sun is excluded, daylighting can provide too much light. This makes it hard for people to see and can reduce productivity.

? Poorly balanced light: If daylight illuminates only parts of a space adequately, and electric lighting is poorly integrated, parts of the space will appear too bright and other parts will look underlit and gloomy in contrast.

? Dark-colored interior surfaces: Dark-colored interior finishes reduce the amount of reflected light. Daylighting potential is wasted.

[25] Daylighting in Schools: An Investigation into the Relationship Between Daylighting and Human Performance. Condensed Report, August 20, 1999. Prepared by Heschong Mahone Group, 11626 Fair Oaks Blvd. #302, Fair Oakds, CA 95628. *www.pge.com/pec/daylight/valid4.html*

[26] From Harmony Library web-site. *www.light-power.org/harmonylib/lev3/daylighting/fr3pitfalls.htm*

? Uncontrolled electric lighting: If electric lighting is left on, even when daylighting provides sufficient illumination, there will be no energy savings and the lighting will produce unnecessary heat that the cooling system must remove.

? Too much solar heat: Daylight can also bring solar heat with it, adding to the demands on the cooling system, increasing energy bills rather than decreasing them. Problems can result from poor placement (east- and west-facing glass, horizontal glass and glass set at an angle), lack of shading, or poor choice of glass type.

### *Tips for Daylighting*

The Harmony Library web site (see footnote 25), as well as other resources referenced in Chapter 4, provide numerous tips and design details for overcoming these pitfalls. Some of the main strategies are to:

? Work with diffuse light from the sky rather than direct sunlight.

? Design for all seasons and times of day. This requires understanding the sun's path and how the energy puzzle varies throughout the year.

? Bring light deep into the building.

? Provide multiple sources of daylight, preferably from at least two sides of every space, to reduce glare and shadowing problems.

? Distribute the daylight by directing it toward ceilings, walls, and floors for gentler and more diffuse light with fewer shadows.

? Use light-colored interior surfaces to reflect daylight and brighten the space.

? Use vertical glass, facing north or south, for best results with daylighting and keeping solar heat out of the building.

***Case Study: Durant Middle School, Raleigh, North Carolina***
From Schools Going Solar, Volume 1: A Guide to Schools Enjoying the Power of Solar Energy, Utility PhotoVoltaic Group (UPVG), *www.upvg.org*

Students at Durant Middle School in Raleigh may not realize their new school is saving US$16,500 a year in energy costs, but they have noticed that their grades are better! Schools incorporating passive solar features—like Durant and six other new schools in Wake and Johnston Counties in North Carolina that use daylighting—not only use less energy, but student grades have improved and attendance is higher. Studies have shown that natural lighting has a positive effect on student attitudes and performance. Test comparisons have proved that students attending daylit schools for two or more years out-perform students in nondaylit schools by 14 percent.

Natural daylighting is featured in all major occupied spaces within Durant Middle School, including classrooms, the cafeteria, and the gymnasium. The school was oriented on an east-west axis, and north- and south-facing monitors on the roof funnel the light inside through a series of baffles which diffuse the light evenly throughout the middle of room. Classroom windows on the north and south walls use "low-e" glazing to prevent heat loss.

Because electric lights also give off heat, using them less reduces the amount of air conditioning needed during the warmer months (students attend Durant throughout the year, including the summer). At Durant, daylighting—combined with a radiant barrier on the roof that reflects the sun's heat and few east and west windows to reduce heat gain from early morning and late afternoon sunlight—lessens the cooling load to about 70 percent of that of a conventional school.

Decreasing the size of the cooling and electrical systems saved US$115,000 in construction costs, while the reduction in total energy use will save US$165,000 per year. The school paid for all of its daylighting features from energy savings within the first six months of operation. And increased performance and fewer sick days for both students and staff mean even greater savings.

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### 3.3.2 Electric Lighting

Electric lighting directly accounts for approximately 20 to 25 percent of the total electrical energy used in the United States. Lighting also has an indirect impact on the total energy use because the heat generated by electric fixtures alters the loads imposed on mechanical equipment. During the cooling season, reduced electric lighting loads also lower air conditioning energy usage.[27]

> ***"Efficient lighting is not just a free lunch; it's a lunch you are paid to eat"***
>
> ***AMORY LOVINS, CO-FOUNDER OF RMI, 1987***

More importantly, electric lighting affects the quality of the building spaces and the productivity of its occupants. It has the potential to enhance or detract from the goal of a superior learning environment. Lighting design is the starting point; skillfully done it can enhance quality while reducing lighting power density. Energy efficient lighting equipment is the second, companion strategy that can lower connected load and energy use still further.

Some primary strategies for designing electric lighting systems are:[28]

? Carefully defining the required lighting

? Putting the right amount of light where it's needed, when it's needed

? Avoiding glare

? Lighting the ceiling and walls

? Blending electric lighting and daylighting

? Eliminating lighting flicker and noise

? Providing good color rendition

Implementation of these strategies requires up-to-date lighting design skills and knowledge of available energy efficient lighting equipment and their performance. There are numerous resources available to assist with equipment selection (see footnote 27). Sustainable lighting should also include careful consideration of outdoor lighting from the standpoint of visibility, energy use, and light trespass and pollution.[29]

Finally, it is important to emphasize that commissioning of lighting systems, as well as occupant education, become very important towards obtaining the maximum energy benefits.

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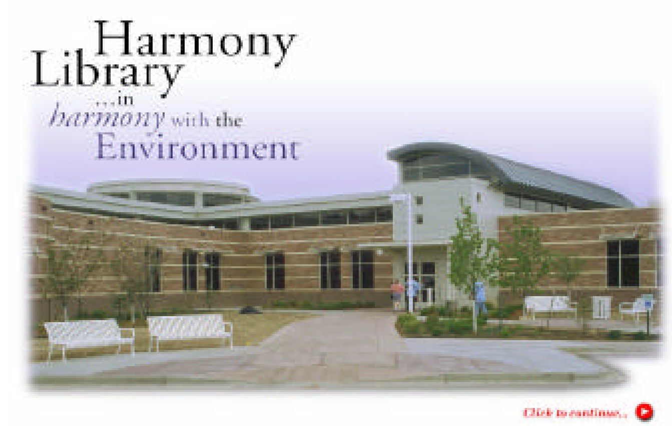
27 *www.uofs.edu/admin/greenlight.html*

28 See the Harmony Library web-site for descriptions of technologies and resources for further assistance: *www.light-power.org/harmonylib/lev2/strategies/fr2strategieselectriclighting.htm*

29 See *www.darksky.org*

***Case Study: Harmony Library, Fort Collins, Colorado***
***(see** www.light-power.org/harmonylib/**)***




By employing an integrated sustainable design approach, the Harmony Library was able to significantly reduce electric lighting power through extensive use of daylighting combined with energy efficient electric lighting. As shown in the table below, Harmony Library is estimated to consume 70 percent less electric lighting power during the day than a conventional building. These strategies, in turn, meant the cooling system could be significantly downsized. (Source: Light Forms, Boulder, Colorado).

| Electric Lighting Power (Watts per square foot) | | | |
|---|---|---|---|
| | Conventional Building | Harmony Library | Percent Savings |
| Day | 1.50 | 0.45 | 70% |
| Night | 1.50 | 0.85 | 43% |

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## 3.4 Energy Efficient Building Shell

***The building envelope isn't a barrier, but a selective pathway that takes advantage of natural energy flows.***

***GREG FRANTA, ENSAR***

A school building's shell consists of exterior walls, roof, foundation, doors, windows, skylights, dampers, and other openings. The objectives for a well-designed building shell are to:

? Minimize infiltration (both outside air leaking in and conditioned air leaking out) to reduce convective heat transfer through the building shell

? Minimize conductive heat transfer

? Control humidity by maintaining proper movement of water vapor in and out of the building

? Control sunlight to reduce HVAC loads and electric lighting needs

Strategies for meeting these objectives typically include the addition of insulation to walls, floors, and roofs; window upgrades or treatments; and shell tightening measures to reduce air infiltration and exfiltration.

### *Glazing*

Design aspects related to glazing -- placement, area, shading, type of glass -- provide huge opportunities to enhance architecture, daylighting, view, heating and cooling, and comfort. Good choices in these areas are critical to a successful building.[30][31]

There have been great advances in high performance glass options over the past two decades that should be investigated during design. Glass with specific properties (u-value, solar-heat gain coefficient, visible transmittance) should be selected for specific applications in order to balance desired outcomes with undesired outcomes (e.g., conductive heat transfer, solar gains, daylighting, radiant comfort). This may mean selecting different glazing for different faces of the building to account for solar orientation. This becomes very important in our climate because unwanted solar gains can significantly contribute to cooling loads.

High performance glass, on a standalone basis, may not look like a good investment compared with standard insulated glass. But when looked at from a systems standpoint in a well-integrated design, it often becomes the least expensive glazing choice.

### *Air Sealing*

It is important to find and concentrate air-sealing efforts on the major sources of air leakage into a building, since they can easily account for a large percentage of the air infiltration.

School buildings may use unconditioned ceiling plenum space as the return air path to the heating or cooling system. Routing of return air leads to substantial air infiltration since return air plenums are depressurized and will draw in surrounding outside air if not sealed. In these situations, plenum surfaces that have connection paths to the outdoors should be sealed (including areas around pipes and other penetrations) to prevent unnecessary air infiltration. For flat,

[30] Glazing Design: Handbook for Energy Efficiency, American Institute of Architects, 1997. 800-242-3837.
[31] *www.light-power.org/harmonylig/lev2/strategies/fr2strategiesglass.htm*.

unventilated roof spaces, add rigid insulation (most cost-effective during new design or a major re-roofing) to maintain return air temperatures, thus saving energy.[32]

## 3.5 Energy Efficient HVAC Systems

***If everything else is done sustainably, the HVAC system should be able to be significantly down-sized***

The sustainable design goal for Heating Ventilation and Air Conditioning (HVAC) Systems is to meet the occupant comfort needs through the most energy efficient and environmentally sensitive means possible. Although this may sound simple, the HVAC system proves to be a pivotal aspect in the design of a sustainable building. The reason is that heating and cooling needs are affected by virtually every other sustainable (or non-sustainable) characteristic of the building. For example, the extent of passive solar design, natural lighting, natural ventilation, insulation and window performance, and even material selection all play a role in the resulting requirements for conditioned air. Therefore, the HVAC system design is a prime example of the importance of integrated, whole-building, design. In essence, if everything else is done sustainably, the HVAC system should be able to be significantly down-sized. Rocky Mountain Institute calls this "tunneling through the cost barrier".[33] With significant downsizing, due to good whole-building design and responsible safety factors, efficiency of the equipment becomes somewhat less critical. The appropriate HVAC system should therefore be selected only after the entire design team has reviewed the contributing thermal loads of these interrelated systems. One local example of this occurred during the design of the Value Plastics building in Fort Collins, Colorado. Due to the performance of the glazing selected, the design team was able to eliminate perimeter baseboard heating from the building.

Aside from ensuring proper system size, the Green Team has identified the following sustainable design goals for HVAC systems in Poudre schools:

? Simple design

? Easy to maintain

? Minimize number of components

? Energy efficient

? Best life cycle cost (including energy, maintenance, and replacement)

? For comfort, configure system for optimum air distribution and pay attention to how surfaces affect radiant comfort

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[32] *www.eren.doe.gov/energysmartschools/elements_shell.html*
[33] Green Development: Integrating Ecology and Real Estate. Rocky Mountain Institute. John Wiley & Sons. 1998

? Low noise

? Avoid equipment in classrooms so maintenance staff can easily access them

? System is flexible for after-hour usage (e.g., when only certain rooms will be in use)

? Staged chilling/heating would be ideal

As noted earlier, these Sustainable Design Guidelines are not intended to be prescriptive or to state requirements for Poudre Schools. However, the Poudre School District Green Team has developed the following list of considerations based upon their own process knowledge and the above listed sustainable design goals:

? Computer labs need their own independent HVAC systems due to different load requirements and after school use.

? Continue the use of Energy Management System (EMS) for controls, ensuring all equipment is compatible with, and controlled by the EMS.

? Chilled water should be considered when adding more than 50 tons of cooling to a building.

? Premium efficiency motors, as defined by the Consortium for Energy Efficiency (CEE), for all motors greater than one horsepower.

? Consider heat recovery air handlers.

In addition to the guidance from Poudre School District, the Green Building Technical Manual, developed by the U.S. Department of Energy's Center of Excellence for Sustainable Development, offers many practical guidelines for integrating sustainability into HVAC system design:[34]

### *General Design Guidelines*

? Explore non-energy-intensive opportunities that harness natural processes such as daylighting, natural ventilation, evaporative cooling, thermal mass coupling, and energy recovery systems.

? Recognize that thermal mass can be beneficial in providing a flywheel effect to reduce after-hours environmental conditioning and morning warm-up loads.

[34] The Green Building Technical Manual: available for download from *www.sustainable.doe.gov*.

- Control the infiltration of unwanted air through sealing and building pressurization.
- Consider increased insulation levels to reduce loss factors.
- Use computer-based analysis tools (such as DOE-2.1, ENERGY-10, TRNSYS, and BLAST) to evaluate building load, select equipment, and simulate system performance. Specify equipment that meets the calculations and do not oversize.
- Design for part-load efficiency and select equipment that remains efficient over a wide range of load conditions.
- Make every attempt to reduce cooling loads by using high performance glazing, overhangs, efficient lighting, etc.

***Air-Delivery Systems***

- Consider the use of variable-air-volume systems to reduce energy use during part-load conditions.
- Reduce duct system pressure losses by using computer-based programs for correct sizing. Strategically locate balancing dampers to improve energy efficiency, and consider the use of round or flat oval ductwork to reduce energy losses and minimize noise.
- Reduce duct leakage and thermal losses by specifying low-leakage sealing methods and good insulation.
- Optimize selection and location of air diffusers to save energy and improve comfort control.
- Use low-face velocity coils and filters to reduce energy loss through components.
- Design equipment and ductwork with smooth internal surfaces to minimize the collection of dust and microbial growth.

***Central Equipment***

- When selecting chillers, consider high performance chillers, integrated controls to increase operational flexibility, and open-drive compressors.
- Evaluate a multiple-chiller system with units of varying size.
- Consider absorption cooling, to permit the use of a lower cost fuel such as steam, natural gas, or high-temperature waste heat, to drive the absorption refrigeration process.

? Consider thermal energy storage to manage the school's utility usage during peak demand.

? Where simultaneous heating and cooling loads occur, evaluate the use of heat-recovery chillers.

### *Energy Efficient HVAC Components*

? Use premium efficiency motors that are properly sized.

? Consider variable-speed drives for reducing energy used by fans, chillers, and pumps under part-load conditions.

? Consider direct-drive equipment options and review actual loss factor on belt- or gear-driven equipment.

? Direct digital control (DDC) systems offer greater accuracy, flexibility, and operator interface than pneumatic systems.

***Grafton Middle School/High School, Virginia Beach, Virginia***

(from Energy Smart Schools web-site, *www.doe.eren.gov/energysmartschools*)

Grafton, completed in 1996, was conceived and designed as an energy efficient building, and features extensive use of daylighting. This combination middle school/high school takes advantage of economies of scale and shared facilities to increase the value received for dollars spent. The 285,000 gross square feet facility is also used by community and extracurricular groups both before and after school hours. Despite the extended hours of operations, recent utility records show significant savings over comparable buildings.

The HVAC system allows the school to heat or cool only a few classrooms instead of entire building wings. Grafton achieved additional energy efficiency through a direct digital control energy management and an advanced central ventilation system. The ventilation system uses desiccant wheel heat recovery to reduce electric refrigeration loads and precondition outside air.

**Contact:** Woody Carmines, Principal of Operations, 405 Grafton Drive, Yorktown, VA 23692, 757-898-0525.

***Disclaimer: This and all other case studies within these guidelines are intended for illustrative purposes only. They do not necessarily reflect in whole, or in part, the products or technologies intended for use, by Poudre School District.***

## 3.6 Environmentally Preferable Building Materials

Environmentally preferable materials are defined as those that have a lesser impact on human health and the environment when compared to products serving the same purpose.[35] Not only do environmentally preferable materials help to improve indoor air quality in schools, but they are more ecologically sensitive when analyzed over their entire life cycle. This cradle-to-grave analysis is the tracing of a material from its initial source availability and extraction, through refinement, fabrication, treatment, transportation, use, and eventual reuse or disposal.

As part of its sustainable design philosophy, Poudre School District intends to use environmentally preferable building materials to the maximum extent possible. However, this can be a complex aspect of sustainable design considering: 1) the vast number of products available claiming to be "green", as well as 2) the numerous factors for comparing products on an environmental basis. Use of environmentally preferable products requires both a prioritization scheme for comparing products, as well as shear time to research specific products, their function, cost, and local availability. Methods to compare products are discussed in Section 3.6.1.

Regarding specific materials, the Poudre School District Green Team has already initiated research into a number of different products. The results of this research are summarized within Section 3.6.2. Finally, because Indoor Air Quality is of major consideration for schools, and greatly influenced by material selection, this topic is covered separately in Section 3.6.3.

### 3.6.1 Evaluation Criteria for Comparing Products

The following table from the City of Fort Collins Facility Design Standards summarizes factors for choosing building products and materials: [36]

[35] EPA Environmentally Preferable Purchasing Guidelines.
[36] City of Fort Collins Facility Design Standards. Prepared by Facilities Division.

| | |
|---|---|
| Energy Efficiency | ? Energy efficient production methods<br>? Use of renewable energy sources |
| Resource Responsibility | ? Minimal need for other materials<br>? Low maintenance<br>? Durability<br>? Efficient use of material<br>? Recycled content<br>? Recyclable |
| Social/Public Health | ? Avoidance of harmful chemicals in production<br>? Reduction of off-gassing<br>? Avoidance of harmful chemicals in disposal and reuse |
| Economics/Functionality | ? Initial cost<br>? Cost savings and payback<br>? Availability<br>? Acceptability |
| Supplier or Manufacturer | ? Local supplier<br>? Local economic benefit<br>? Suppliers with in-house environmental programs |

When selecting products, it is important to consider that:

? **Natural materials** are generally less energy intensive, less polluting to produce, and contribute less to indoor air pollution than synthetic materials.

? **Local materials** have less energy cost and air pollution associated with their transportation and can help sustain a local economy.

? **Durable materials** can save on maintenance costs, as well as installation of replacement products.

It is also helpful to prioritize products by origin, taking care to avoid materials from nonrenewable sources:

? **Primary Materials** - those found in nature such as stone, earth, flora (hemp, jute, reed, wool), cotton, and wood.
- Ensure new lumber is from certified sustainably managed forests or certified naturally felled trees.
- Use caution that treatments, additives, or adhesives don't contain toxins or off-gas volatile organic compounds (VOCs).

? **Secondary Materials** - those made from recycled products such as wood, aluminum, cellulose, and plastics.
- Verify that production doesn't involve high levels of energy, pollution, or waste.
- Verify functional efficiency and safety of salvaged materials.

- Look at the composition of recycled products, toxins may still be present.
- Consider cellulose insulation.
- Specify aluminum from recycled material; it uses 80 percent less energy to produce over initial production.
- Keep alert for new developments; new recycled goods are coming on the market every week.

? **Tertiary Materials** - manufactured materials (artificial, synthetic, nonrenewable) having varying degrees of environmental impact.
  - Avoid use of materials containing or produced with chlorofluorocarbons or hydrochlorofluorocarbons that deteriorate the ozone layer.
  - Avoid materials that off-gas VOCs.
  - Minimize use of products made from new aluminum or other materials that are resource disruptive during extraction and a high energy consumer during refinement.

### 3.6.2 Product Research Results for Poudre Schools

The following are products studied and compiled by the Poudre School District Green Team. Additional detail about each product's sustainable features, as well as contact information can be found in Appendix A. Poudre School District does not necessarily endorse these products. The list is not exhaustive, it simply contains items that the Green Team considers to have merit for further evaluation during design.

**DIVISION 2-SITE WORK**

**Synthetic Turf**
? Reduces maintenance cost
? Reduces water costs
? Less wear

**Field Turf**
? Conserves natural resources
? Makes use of renewable resources
? Reduces dependence on offsite utilities
? Reduces building maintenance
? Durable with less wear

**Beachrings2 (portable boardwalk)**
? Makes use of renewable resources
? Reduces building maintenance
? 100 percent recycled resource

**DIVISION 3-CONCRETE**

**Insulated Concrete Forms (Lite Form, Fold Form, E-Z Form)**
? Conserves natural resources

? Increases energy efficiency
? Ease of installation
? Durable and long-lasting

**Rastra Panels: All the benefits of Insulated Forms (see above), plus:**
? Made from recycled plastic form
? Fire proof
? Stable in any climate
? Reduced air infiltration

**Faswall**
? Conserves natural resources
? Makes use of renewable resources
? Increases energy efficiency

**DIVISION 6-WOOD AND PLASTIC**

**Generic-Particleboard**
? Conserves natural resources
? Makes use of renewable resources
? Decreases environmental emissions

**DIVISION 7-THERMAL MOISTURE PROTECTION**

**Geric-Polyisocyanurate roof insulation**
? Increases energy efficiency
? Reduces building maintenance

**DIVISION 8-DOORS AND WINDOWS**
? Conserves natural resources
? Makes use of renewable resources
? Increases energy efficiency
? Reduces building load
? Reduces building maintenance

**DIVISION 9-FINISHES**

**Acoustical Ceilings**
? Conserves natural resources
? Makes use of renewable resources
? Contains pre and post consumer recycled content

**Armstrong Recycled Content Ceiling Tiles**
? Conserves natural resources
? Makes use of renewable resources

**Soundsoak**
? Conserves natural resources
? Makes use of renewable resources
? Decreases environmental emissions

**Water Based Latex Paint**
? Decreases environmental emissions
? No VOC's

**Livos Paints and BioShield Paint**
? Non-toxic, plant based ingredients.
? Great variety of colors.
? Safe for contractors & inhabitants.
? Long lasting and easy to renovate.
? For allergy-prone and chemically sensitive people
? Sustainable ingredients farmed without pesticides.

**Naturestone**
? Made from scrap material that would be waste in a landfill.
? Natural resin emits no VOC's

**PET Carpeting**
? Made from 100 percent recycled plastic (pop bottle)
? Is available with recycled textile carpet pad

**Powerbond RS Carpet-Collins & Aikman Floorcoverings**
? 100 percent recycled and recyclable backing
? No factory applied adhesives
? No off-gassing from wet adhesives during production or instillation

**Bamboo Flooring**
? Renewable resource
? Manufactured with environmentally safe adhesive
? Harvested from managed and certified growth areas

**Rajastan Silk Wallcovering**
? 100 percent natural
? Renewable resource

**Sisal Wall Covering**
? Natural renewable resource
? Biodegradable
? Never tested on animals.

**Farbo-Natural Linoleum**
? Makes use of renewable resources
? Decreases environmental emissions
? Made of primarily natural raw materials

? Contains linseed oil, rosins, and wood flour, calendered onto a natural jute backing
? Hypo-allergenic

## DIVISION 10-SPECIALTIES

**Ecosystem Monospace Elevator**
? Conserves natural resources
? Increases energy efficiency
? Decreases environmental emissions
? Reduces dependence on offsite utilities

**Certified Forest Products**
? Utilizing lesser know species in lieu of a handful of standards alleviates pressure on species that are threatened with extinction from overharvesting.
? All wood products are from Forest Stewardship Council certified

**Low flow plumbing fixtures**
? Saves water with every use
? Compact cistern design with concealed trap for easy cleaning

**Comp Tainer**
? Conserves natural resources
? Makes use of renewable resources
? Increases energy efficiency
? Reduces dependence on of site utilities

## DIVISION 12-FURNISHINGS

**Second Site Systems**
? Conserves natural resources
? Makes use of renewable resources
? Reduces building maintenance

**Harter Ergonomic Seating**
? Manufacturers commitment to reduce environmental impacts

**Ecowork Modular Office Furniture**
? Conserves natural resources
? Makes use of renewable resource
? Decreases environmental emissions

**Recycled Plastic Park Benches**
? Conserves natural resources
? Makes use of renewable resources
? Reduces building maintenance

**DIVISION 15-MECHANICAL SYSTEMS**

**Trane Chiller Systems**
? Conserves natural resources
? Increases energy efficiency
? Decreases environmental emissions

**Bauderus Boilers**
? Conserves natural resources
? Increases energy efficiency
? Decreases environmental emissions

**Aaon Air Handlers**
? Conserves natural resources
? Increases energy efficiency
? Reduces building load

**McQuay Chiller**
? Conserves natural resources
? Increases energy efficiency
? Decreases environmental emissions
? Reduces building maintenance

**DIVISION 16-ELECTRICAL**

**3M Light Pole**
? Conserves natural resources
? Makes use of renewable resources
? Increases energy efficiency
? Reduces building load

**Fiberstar Fiber Optic Lighting**
? Increases energy efficiency
? Reduces building maintenance

**Green Lighting/Energy Efficient Lighting-Lumatech**
? Unit provides light output equivalent to an incandescent lamp, but with one third the wattage
? Long lasting ballast and lamp
? Significantly reduces electricity and labor costs
? Produces the best possible light and color rendition using the least amount of money
? 10 year warranty

**Solatube Lighting**
? Uses natural daylight
? Saves money -reduces need for artificial light
? Brightens 150 foot area

**SM Lightpipe**

? Removes source of heat from room, reducing building load
? Increases energy efficiency
? Makes use of renewable resource
? Conserves natural resources

**Fiber Optic Tube Light**

? Increases energy efficiency
? Reduces building maintenance

**Natural Gas Turbine Generator**

? Conserves natural resources
? Increases energy efficiency
? Reduces dependence on offsite utilities
? Reduces building load
? Reduces building maintenance

**Sentry Switch Lighting Controls**

? Increases Energy Efficiency

**Wattman Lighting Voltage Controller**

? Increases energy efficiency
? Reduces building load
? Reduces building maintenance
? Reduces voltage of HID fixtures keeping light level at a constant
? Increases life of fixture

**Lateral Twisted Tube Fluorescent**

? Increases energy efficiency
? Reduces building maintenance
? Requires less wattage with greater lumen output

***Case Study: Environmentally Preferable Building Material Selection for the Central Supply Facility at Argonne National Laboratory***

This 19,000 square foot building addition will include office space and a high bay shipping, receiving, and storage area for centrally managing material supplies at Argonne National Laboratory in Argonne, Illinois. The design team employed sustainable principles throughout the design and is pursuing LEED™ certification for its efforts. In addition to several energy efficiency and daylighting features, the construction specifications include the following environmentally preferable building products and construction practices:

- natural linoleum flooring
- recycled content carpet tile
- native trees in landscape
- recycled content parking curbs
- low VOC and lead free paints
- recycled content ceiling tiles
- recycled content plastic restroom dividers
- gypsum board with 10 percent recycled content
- construction site recycling required in specification (see Section 3.9)
- building commissioning (see Section 3.10)

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### 3.6.3 Indoor Air Quality

*Why IAQ is Important to Schools*

***"We know that fresh air, proper circulation, and managing humidity is important in our homes. Why should we think it wouldn't also be true in a school?"***

***CAROL BROWNER-EPA ADMINISTRATOR***

Environmental Protection Agency (EPA) studies of human exposure to air pollutants indicate that indoor levels of pollutants may be 2 to 5 times, and occasionally more than 100 times, higher than outdoor levels. These levels of indoor air pollutants are of particular concern because it is estimated that most people spend about 90 percent of their time indoors. Comparative risk studies performed by EPA and its Science Advisory Board have consistently ranked indoor air pollution among the top four environmental risks to the public.

***Failure to prevent indoor air problems, or failure to act promptly, can have consequences such as:***

? increasing the chances for long-term and short-term health problems for students and staff

? impacting the student learning environment, comfort, and attendance

? reducing productivity of teachers and staff due to discomfort, sickness, or absenteeism

- ? faster deterioration and reduced efficiency of the school physical plant and equipment

- ? increasing the chance that schools will have to be closed, or occupants temporarily moved
- ? straining relationships among school administration, parents, and staff

- ? creating negative publicity that could damage a school's or administration's image and effectiveness

- ? creating potential liability problems

Indoor air problems can be subtle and do not always produce easily recognized impacts on health, well being, or the physical plant. Children are especially susceptible to air pollution. For this, and the reasons noted, air quality in schools is of particular concern. Proper maintenance of indoor air is more than a "quality" issue; it includes safety and good management of our investment in the students, staff, and facilities.[37]

***Chemicals, sources to avoid, and their reactions:***

- ? ***Benzene*** found in synthetic fibers and plastics: highly toxic to red blood cells

- ? ***Acetone*** found in masonry, caulking, wallcoverings, strippers, adhesives, polyurethane, stains and sealers

- ? ***Toluene*** found in adhesives, paint remover, paint: may cause lung damage: flammable

- ? ***Dichloromethane*** found in solvent in paint remover, adhesive paint aerosols: may cause cancer, heart attacks: a known water pollutant

- ? ***Ethylene glycol*** found in solvent in latex paint: may cause damage to blood & bone morrow

- ? ***DEHP*** found in plasticizer used in wallcovering, floorcover, to keep vinyl flexible: known carcinogen

- ? ***Dioxin*** found in PVC products; most toxic, low levels cause cancer, endocrine disruption

- ? ***Terpene*** found in natural pine and cedar wood furniture, and linoleum: may cause allergic reactions

[37] *www.epa.gov/iaq/schools*

? ***Formaldehyde*** found in plywood, particleboard, adhesives, fabric finishes, carpet padding

? ***4-PC*** natural result of binding latex to carpet: may cause allergic reaction

## 3.7 Water Conservation

> ***"When the well is dry, we know the worth of water."***
>
> ***BENJAMIN FRANKLIN- STATESMAN & SCIENTIST 1790***

Water is a precious resource that should be used efficiently indoors and out. Conserving water in schools saves money, but the ramifications of water efficiency go far beyond lower water bills. For example, at the community level it can help to eliminate or defer the need for more dams, treatment facilities, and expensive water rights. Water treatment consumes a great amount of energy. A large percent of the treated water ends up being flushed in toilets and used to water landscaping. Whenever water can be saved, so can energy, and the energy savings often financially dwarf the water savings. Installing water-efficient appliances and fixtures, using drought resistant plants in landscaping, and changing irrigation practices can reduce water consumption by 30 percent or more.

In order to conserve both water and energy to the extent possible, the following steps are applied to the sustainable design process:

1) Minimize the amount of water required to operate the school both indoors and outside.

2) Evaluate the various water uses, distinguishing those that can be performed using raw (untreated) water, versus functions requiring treated water.

3) Evaluate methods for providing the required raw water supply using on-site resources.

> ***Building Principles to Conserve Water***
>
> ***1. Install plumbing fixtures and appliances that conserve water.***
> ***2. Plant a water efficient landscape (Xeriscape).***
> ***3. If landscape watering is needed, use an efficient irrigation system.***
> ***4. Design the landscape to prevent water from running off the property.***

For Step 3, example methods include harvesting rainwater, collecting and treating storm water runoff via constructed wetlands, and on-site biological wastewater treatment systems. These features are included in case studies of sustainable schools. However, none would be feasible for Poudre School District, either because of Colorado water rights laws, or due to code restrictions for on-site wastewater treatment. Therefore, the emphasis for Poudre School District should be on water conservation through landscape design and efficient fixtures within the school building.

### *Water-efficient landscaping*

Efficient use of water should be a primary concern in the development of a landscaping plan for a sustainable school. The proper selection of plants, irrigation equipment, and irrigation scheduling can dramatically reduce water waste. Outdoor water use varies widely from place to place and climate to climate but on average 50 percent of water use occurs outside. Much of this water is wasted, either because it's applied to inappropriate landscaping, or because it is applied in the wrong way at the wrong time in the wrong quantities.

Ways to cut down on outdoor water waste in landscaping:

? Consider using grasses, trees, bushes, and shrubs that require less water (e.g., wheatgrass or buffalo grass instead of bluegrass), with attention to durability and wear.

? Install drip irrigation systems to water trees, shrubs, and bushes.

? Program automatic sprinkler systems correctly to maximize irrigation systems.

? Install and connect buried moisture sensors to irrigation timers to deliver the right amount of water to the root zone and to shutoff irrigation systems during rain.

? Preserve natural landscaping during construction.

? Zone planting for efficient irrigation.

## 3.8 Recycling and Waste Management

Sustainable schools should not only consider the building itself, but they should be designed to foster sustainable practices within the building. For example, one requirement for all LEED™ certified sustainable buildings (see Section 2.5) is that the building be designed for storage and collection of recyclables. Most schools within Poudre School District are already recycling on some level. However, there is room for improving upon these systems and to expand them to possibly include additional materials. Furthermore, some schools are experiencing difficulty with recycling due to lack of storage space. Part of the sustainable design process should include an examination of current recycling practices in Poudre schools, and design provisions for continuing and improving upon these recycling systems in new schools. Also, collection systems should be designed to minimize labor costs. For example, chute systems that drop recyclables to central collection areas may save money. The following suggestions are from PSD food services staff involved with the district's solid waste recycling program.

Ensure that the following areas have space allocated for recycling the specified materials:

? Cafeteria: aluminum cans, glass bottles, plastic bottles, and grease from deep-fat fryers

? Receiving Areas: cardboard and cans (e.g. #10 cans)

? All Areas: Office paper, newspaper, and magazines

? Custodial: packaging and custodial supply containers

There may be special solid waste and recycling requirements for Art rooms, Science rooms, and the nurse's office. Finally, the design should take into account provisions needed for recycling in areas where public events occur during off-hours. The most common spaces used are cafeterias, gymnasiums, athletic fields, and media centers.

In addition to solid waste recycling, Poudre School District has been investigating the feasibility of composting cafeteria wastes, as well as leaves and grass clippings from grounds keeping. One possible strategy is the use of containerized compost systems. This would require allocation of space for these containers during site planning.

Aside from the benefits of solid waste recycling, another reason for composting in schools is that it provides a rich topic for scientific investigation and discovery (see Section 3.11). Because it is a process that relies on biology, chemistry, and physics, it can be used for a wide range of scientific projects or experiments and can help students to see the interconnections between various scientific fields.[38]

## 3.9 Construction Waste Reduction and Recycling

As noted earlier, Poudre School District intends to apply sustainability to the design, construction, operation, and ultimate dismantling of its school buildings. This section describes sustainable construction methods and how to incorporate them into the design/build process. Utilizing construction methods that minimize waste generation is critical, for it is estimated construction-related waste accounts for about one-fourth of total landfill waste in the United States. Yet many construction materials can be recycled, including glass, aluminum, carpet, steel, brick, and gypsum. It is estimated that 50 to 80 percent of construction and demolition (C&D) waste is potentially reusable or recyclable, depending on the type of project and local markets for waste materials.[39]

Strategies for applying sustainability to construction practices include:

? use of waste reduction techniques during construction;

? reuse of construction waste material on the construction site;

? salvage of construction and demolition waste material from the construction site for resale or reuse by others;

? return of unused construction material to vendors for credit; and

[38] *www.cfe.cornell.edu/compost/.*
[39] Waste Spec: Model Specifications for Construction Waste Reduction, Reuse, and Recycling. Published by Triangle J Council of Governments. P.O. Box 12276, Research Triangle Park, NC 27709, (919) 549-0551. July 1995.

? recycling of construction and demolition waste for remanufacture into new products.

To implement these strategies, there needs to be clear communication of expectations and goals from Poudre School District and its design agents, to the construction contractor and its subcontractors. There are several methods for achieving this through changes to construction specifications:

? ***Using bid alternates*** to evaluate the economic feasibility for undertaking specific recycling measures as an alternative to landfilling waste.

? ***Requiring recycling to the extent practical*** in specification language, including possible requirements to track what was recycled and where it went. The specification language would be reinforced in the pre-bid meeting, pre-construction meeting, and regular job-site meetings.

? ***Requiring a waste management plan*** for approval by Poudre School District. The plan requirements would be included in project specifications and may include such items as expected waste volumes, disposal methods, and costs; items to be recycled; arrangements for construction site recycling and indoctrination of subcontractors.

? ***Requiring recycling of specific items*** such as concrete, metal, glass, etc.

? ***Subtracting waste costs and substituting a waste manager.*** Under this approach, each contractor would be required to include a line item in its bid for disposal cost. This amount would then be subtracted from the final bid and an independent waste manager hired to handle all waste recycling and disposal.

There is precedent for each of these strategies that needs to be further investigated and applied within Poudre School District on a project by project basis.[40] Selection of the most appropriate strategy would depend on project circumstances, as well as changing markets for recyclable C&D materials and local landfill tipping fees.

In addition to these general strategies, the following more specific practices should also be considered for inclusion in construction specifications:

? Design the building to "common size" lumber sizes to reduce waste from cutting custom sizes.

? Verify field measurements before confirming product orders to minimize waste due to excessive materials.

? Coordinate product delivery to minimize site storage time and potential damage to stored materials.

[40] Using Specifications to Reduce Construction Waste. Published by Triangle J Council of Governments. P.O. Box 12276, Research Triangle Park, NC 27709, (919) 549-0551.

? Arrange for the return of packing materials, such as wood pallets.

? Store and handle materials in a manner as to prevent loss from weather and other damage.

? Prevent contact with material that may cause corrosion, discoloration, or staining.

? Use only non-hazardous materials in the final cleanup.

? Use the least toxic sealants, adhesives, sealers, and finishes necessary to comply with the construction specifications.

Beyond minimizing construction waste, sustainable construction practices also minimize site impacts. Some suggested approaches to achieve this are to:

? Protect existing and proposed landscape features from damage or contamination.

? Require that all marketable trees designated for removal are sold.

? Require all other vegetation to be chipped for mulching and composting or for use as mill pulp or process fuel.

? Provide on-site locations for as much excavated rock, soil, and vegetation as possible.

? Assess suitability of site for application of pulverized gypsum waste as soil amendment or for striping athletic fields, instead of using marble dust.

## 3.10 Commissioning

Commissioning is defined as "documented confirmation that building systems function in compliance with criteria set forth in the project documents to satisfy the owner's operational needs." This definition is based on the critical understanding that the owner must have some means of verifying that their functional needs are rigorously addressed during design, construction, and acceptance.[41]

Commissioning can be thought of as the step that bridges the gap between a sustainable school on paper, and the fully functional, energy efficient, sustainable school in practice. Essentially, commissioning verifies that building systems perform as intended, so that the anticipated benefits of sustainable design become a reality. It also provides a communications conduit from the design team, to the facilities staff charged with the day-to-day operation of the school building. Commissioning is a required component for LEED™ certified buildings (see Section 2.5) and will be evaluated for new schools constructed within Poudre

[41] *www.bcxa.org*

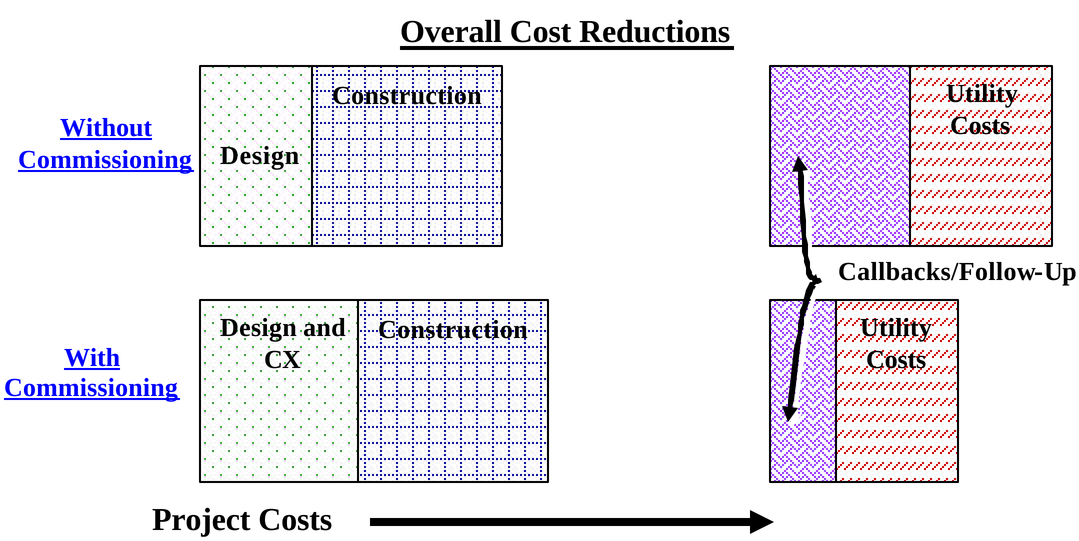
School District. Commissioning is not new to school districts in Colorado. It has been performed on upgrades to building systems, as well as to new school construction in Boulder Schools, Thompson Schools, and Denver Schools.[42]

### *Benefits of Commissioning*

- Larger and more sustained energy savings
- Reduced maintenance costs
- Reduced warranty and follow-up
- Fewer construction litigation problems
- Better building systems operation
- Greater budgeting accuracy

### *Costs of Commissioning*

As shown in the figure that follows, commissioning reduces overall project costs, by reducing construction costs, follow-up costs, and operational costs. However, there are added costs for commissioning. For schools in Boulder, Thompson, and Denver school districts, the cost for commissioning has ranged from 4 to 17 percent of total project cost, or 3 to 6 percent of mechanical, electrical, plumbing (MEP) costs. Given results from a number of projects, a simple payback of one to four years would be a realistic expectation for Poudre schools.[43] Despite the cost savings and relatively quick payback, one obstacle to commissioning is that there are generally separate budgets for design and construction versus operations and maintenance.




[42] From Commissioning presentation at the Sustainable Design Workshop: An Integrated Approach, Fort Collins, Colorado, March 2000. Presentation provided by Jack Wolpert, E-Cube, Inc., Boulder, Colorado, *www.ecube.com*.

[43] Wolpert, J.S. and Deall, J., "What Building Owners Should Know About Building Commissioning: And How to Achieve Buy-In From O&M Staff", E Cube, Inc., Boulder CO, Paper submitted to GLOBALCON '99, Denver, Colorado, April 7-8, 1999.

***Commissioning Approach***

Poudre School District will determine the level of commissioning appropriate on a project by project basis. For new construction, commissioning will likely be integrated into project planning phases so that the project team understands the goals and procedures of commissioning. Elements of commissioning to be considered for integration into project management methods include:

? Establish expected outcomes, such as how the building should perform, what the occupants need, and how much it costs.

? Measure or predict the basic functional, energy efficient, and thermal/environmental performance of the building's automatic control, heating, air conditioning, refrigeration, lighting, and other important energy systems.

? Test building equipment to make sure it works correctly, with other equipment, and meets the present design and operational specifications.

? Provide building system documentation for future operations and maintenance so the school will continue to perform reliably and reap the expected savings.

? Verify that building and system operators have received appropriate training.

EnergySmart schools encourage school decision-makers to incorporate these components in their construction programs.[44]

## 3.11 Eco-Education

***What is Eco-Education?***

Eco-Education refers to the use of the school building itself as a tool for demonstrating and teaching sustainability principles to students.

> ***"The curriculum embedded in any building instructs as fully and as effectively as any course taught in it."***
>
> ***David Orr,***
> ***Oberlin College***

***Why is Eco-Education important?***

As noted in Chapter 1, the full benefits of a sustainable school are not realized if the building itself is not used to teach students about sustainability and their role in a sustainable future. Colorado Content Standards have clearly identified concepts related to sustainability as important to a student's education. Despite this fact, schools and classrooms continue to be designed and built that are inadequate vehicles for teaching sustainability. The full benefits of sustainable design are lost if faculty and students are either unaware of the building's sustainable features or cannot access them. Furthermore, by its very definition

[44] Energy Smart Schools a Campaign of Rebuild America U.S. Department of Energy. March 15, 2000.

"to meet the needs of the present without jeopardizing the ability of future generations to meet their own needs",[45] sustainability implies an imperative to educate students on their role in perpetuating a sustainable future.

### *What are some strategies to enhance Eco-Education?*

- make building systems visibly and physically accessible,
- provide feedback (including real time data) so students can see and measure the impact of their actions on building operations,
- provide students with a connection to the natural environment, and
- document sustainable features and their benefits, then share results with faculty, staff, and students.

### *How can a sustainable building help deliver science curriculum?*

The remainder of this section outlines examples of how a sustainable school can help teach the science curriculum defined in the Colorado Model Content Standards for Science. For each of the six standards listed in the Colorado Model Content Standards, excerpts for grades K-4 are provided, along with examples of sustainable features for demonstrating the standard. These are provided as examples only and are not intended to represent an exhaustive list of possibilities in eco-education. The purposes of the outline are to:

1) demonstrate the compelling alignment between Colorado science requirements and sustainable design, and

2) stimulate ideas for sustainable features that can help teach the science curriculum.

Because the Sustainable Design Guidelines will initially be used to design the next prototype elementary school, excerpts for grades K-4 only are provided. The possibilities become even more compelling for higher level grades. Furthermore, it should be noted that the following outline provides a comparison between sustainability and science curriculum only. Sustainability can help deliver virtually every area of curriculum.

Following are examples of sustainable features for teaching Colorado model content standards for science.

[45] 1987. *Our Common Future***.** Report by the World Commission on Environment and Development (Bruntland Commission)

***Standard 1: Students understand the processes of scientific investigation and design, conduct, communicate about, and evaluate such investigations***

| | | |
|---|---|---|
| "Selecting and using simple devices to gather data related to an investigation." | ? | Expose walls and include samples of different insulation, window systems, etc. Provide instruments to measure performance differences. |
| "Using data based on observations to construct a reasonable explanation." | ? | Connect electric and water meter to the computer network; provide LED display of real time energy use. |

***Standard 2: Physical Science: Students know and understand common properties, forms, and changes in matter and energy***

| | | |
|---|---|---|
| "Making observations and gathering data on quantities associated with energy, movement, and change." | ? | Use different energy sources, including renewables (and see above for providing access to data describing system performance). |

***Standard 3: Life Science: Students know and understand the characteristics and structure of living things, the processes of life, and how living things interact with each other and their environment.***

| | | |
|---|---|---|
| "Giving examples of how organisms interact with each other and with nonliving parts of their habitat." | ? | On-site pond for irrigation can serve dual purpose of learning aquatic biology. |
| "Recognizing that green plants need energy from sunlight and various raw materials to live, and animals consume plants and other organisms to live." | ? | Design landscape for bio-diversity and for native plants. |

***Standard 4: Earth and Space Science: Students know and understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.***

| | | |
|---|---|---|
| "Recognizing that fossils are evidence of past life." | ? | Fossils in pathways outdoors. |
| "Identifying major features of Earth's surface (e.g., mountains, rivers, plains)." | ? | Landscape design to reflect "bioregions". |

| | | |
|---|---|---|
| "Recognizing that the sun is a principal source of Earth's heat and light." | ? | Solar panels; solar hot water heater; daylighting. |
| "Recognizing how our daily activities are affected by the weather". | ? | Real time energy data will show how much more energy the building consumes during cold days. |
| "Describing existing weather conditions by collecting and recording weather data (e.g., temperature, precipitation, cloud cover)". | ? | Weather station and periscope from science classroom. |
| "Recognizing the importance and uses of water (e.g., drinking, washing, irrigating)". | ? | Water measuring devices for comparing flow from different fixtures. |
| "Describing the motion of Earth in relation to the Sun, including the concepts of day, night, and year". | ? | Sundial |
| "Recognizing the characteristics of seasons." | ? | Sundial |
| "Identifying basic components of the solar system." | ? | Provide to scale model of solar system on grounds. |

***Standard 5: Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.***

| | | |
|---|---|---|
| "Describing resource-related activities in which they could participate that can benefit their communities (e.g., recycling, water conservation)." | ? | Design school to facilitate implementation of on-site recycling programs for paper, glass, plastic etc.. Consider feasibility of on-site composting operation. |

***Standard 6: Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines.***

| | | |
|---|---|---|
| "Describing and comparing the components and interrelationships of a simple system (e.g., tracking the continuous flow of water through an aquarium, filter, and pump)". | ? | Make building systems accessible so students can study them. For example so they can trace where air is drawn into the building, how it is heated, distributed, and exhausted from the building. Similarly for water. Where does it come from, how is it routed in the building, where does it go? |

***Case Study: Eco-Education at Work -- Yampah Mountain High School***
(by Susy Ellison, Yampah Mountain High School, Glenwood Springs, Colorado)

In an attempt to create a population that is aware of the connections between natural systems and human shelter, students at Yampah Mountain High School will be building a 500 square foot classroom, on school grounds, utilizing strawbale construction techniques. Last year, those students worked with experts in our community to gain the information and skills that helped them design this classroom. As the final project for that class plans were drawn up, given an engineer's stamp of approval, and submitted to the state for approval by their building department. Our students were challenged to create a structure that demonstrated their understanding of basic ecological principles; researching building materials and selecting those with low embodied energy (sustainably produced with minimal transportation needs and low energy costs for production and maintenance), using recycled or re-used building materials, minimizing construction waste, incorporating passive solar design concepts to minimize heating needs, and utilizing a grid-tied photovoltaic system for their electricity.

Upon completion, the building will be the curriculum. Students spend approximately 184 days in school each year; the setting for their educational activities should be as important as the activities themselves. During construction students will create an informational notebook and exhibit describing the design and construction process in detail as well as demonstrating the ecological principles that were utilized in the building's design. The building will be available as classroom space for all our students. Classes utilizing it will be able to learn about how and why the building was constructed while comparing what they see and feel to experiences in more traditionally designed and constructed facilities. The PV system will incorporate meters that will enable students to monitor both electricity production and consumption. Education involves so much more than merely reading books to glean information. This building will provide a venue for hands-on learning while teaching (both actively and subliminally) about the importance of connecting shelter with landscape.

***Disclaimer: This and all other case studies within these guidelines are intended for illustrative purposes only. They do not necessarily reflect in whole, or in part, the products or technologies intended for use, by Poudre School District.***

# 4.0 Tools and Resources for Designing Sustainable Schools

This chapter is intended to introduce the reader to a number of tools and resources available to assist Poudre School District and its consultants with designing and building sustainable schools. For additional assistance with specific topics within these guidelines, consult the resources cited in footnotes throughout the text.

**<u>Local Tools and Resources</u>**

*City of Fort Collins Utilities. Design Assistance Program*
Fort Collins Utilities has supported integrated, environmentally-responsive design in a pilot program for several years. This includes cost-sharing incremental design costs with the client for increased emphasis on energy efficiency and whole-building design.
*Contact: Doug Swartz, Energy Services Engineer, 970-221-6700, dswartz@ci.fort-collins.co.us*

*City of Fort Collins Utilities. WaterSHED Program*
The City's Stormwater Quality WaterSHED program (Stormwater, Habitat, Education, Design), works with local elementary school science curriculum to provide outdoor educational opportunities.
*Contact: Kevin McBride, 224-6023, kmcbride@ci.fort-collins.co.us*

*Institute for the Built Environment at Colorado State University*
The IBE offers continuing education courses in Sustainable Design, as well as facilitation services for sustainable design charrettes. The mission of the Institute for the Built Environment (IBE) is to foster stewardship and sustainability of the built environment through a research-based, interdisciplinary educational forum. The goals of IBE are to: 1) Optimize the resources of the environment; 2) encourage human equality and cultural sensitivity in the design process and products of the built environment; 3) promote understanding and collaboration among the disciplines and allied professions that shape the built environment; and 4) create a leading-edge, multidisciplinary knowledge base for the built environment.
*Contact: Brian Dunbar, Director, 970-491-5041, dunbar@cahs.colostate.edu*

*City of Fort Collins Green Building Criteria*
A local adaptation of the LEED™ rating system developed by the City of Fort Collins Facility Services Division. Available for download from *www.ci.fort-collins.co.us.*

*Harmony Library Kiosk and Web Site*
Describes the integrated design process applied to a new building in Fort Collins. A kiosk at the library runs a web site describing the design process, challenges, energy efficiency strategies, and benefits. Much of the information is generally applicable to other projects. *www.light-power.org/harmonylib/*

## State-Wide Resources

*AIA Colorado*
Sustainable Design database for Colorado and the Western Mountain Region, compiled by the AIA Committee on the Environment.
*www.aiacolorado.org*

*Colorado Department of Public Health and Environment*
Build for the Future. Bound report providing state-wide resources for sustainable building practices including vendor contact information.

## School-Specific Resources

*Energy Smart Schools*
A campaign of Rebuild America, U.S. Department of Energy
*www.eren.doe.gov/energysmartschools*

*Schools Going Solar*
A guide to Schools Enjoying the Power of Solar Energy, Volumes 1 and 2. Web-site collection of fact sheets on daylighting and other solar applications. Utility PhotoVoltaic Group (UPVG), 202-857-0898, www.ttcorp.com/upvg/schools/

*Campus Ecology - Sustainable Buildings*
Case studies from several sustainable buildings on college campuses nation-wide.
www.wwf.org/campus

## General Resources

*The Sustainable Building Technical Manual*
A manual for designing, operating, and maintaining environmentally friendly buildings. Over 300 pages of detailed suggestions written by over 24 leading experts. Designed to synthesize the large volume of information available on green buildings. Very comprehensive.
*Contact: DOE Center of Excellence for Sustainable Development, 1617 Cole Blvd., Golden, CO 80401, available for download from http://www.sustainable.doe.gov*

*The Sustainable Building Sourcebook*
Created by the Austin Green Builder Program, this 400-page document is being converted to html format for direct download from http://www.greenbuilder.com/sourcebook/. Contains sections on water, energy, building materials, and waste.

*Environmental Building News*
www.ebuild.com
Newsletter and web-site on environmentally sustainable design and construction.

*Center for Resourceful Building Technology (CRBT) Guide to Resource Efficient Building Elements*
Detailed guide for resource efficient material selection and construction methods. Covers foundations and block walls, framing, panel systems, sheathing and wallboard, roofing, siding and exterior trim, insulation, windows and doors, interior finishes, floor coverings, salvaged materials, landscaping, job site recycling, and indigenous building. For each topic covered, an overview is provided followed by a listing of vendors and contact information. P.O. Box 100, Missoula, MT 59806. *www.montana.com/CRBT*. 406-549-7678.

*AIA Environmental Resource Guide*
This 600 page 3-ring binder contains information for design professionals to incorporate environmental criteria into design decisions. It is well formatted with easy access to both in-depth product detail and at-a-glance reference charts. Contains Project Reports of case studies, Application Reports comparing material performance and environmental concerns within product categories, and Materials Reports detailing life-cycle impacts in 20 categories of building materials.
*Contact: AIA Order Department, 9 Jay Gould Court, PO Box 753, Waldorf, MD 20604, Phone: 800/365-ARCH, fax: 800/678-7102*

*Waste Spec*
This 114-page binder provides architects and engineers with background information and model language for addressing waste reduction, reuse, and recycling before and during construction and demolition. Contains specifications tailored to all sixteen divisions of the CSI format. Includes a sample waste management plan for construction contractors. Comes with a disk containing model specifications in a generic format that can be cut and pasted into a specifier's standard specifications.
*Contact: Triangle J Council of Governments, P.O. Box 12276, Research Triangle Park, NC 27709, (919) 549-0551*

*Green Spec*
A database of green products and practices organized by CSI Masterformat. Includes the pros and cons of the existing product or methodology and the green alternative and supplies specification language, which the user can incorporate into their own project. Cost: $125
*Contact: Kalin Associates, 154 Wells Ave., Newton Centre, MA 02159, (617) 964-5477*

*Resources for Environmental Design Index (REDI)*
A free database of over 1,800 companies providing green products and services. Can search by CSI division or by company name. The Web version, located at http://oikos.com/index.html is updated weekly. Three times a year, all companies in the database are contacted for current information.
Web: http://oikos.com/, E-mail: iris@oikos.com

*NPS Sustainable Design and Construction Database*
The sustainable design portion of the database contains over 1000 products that can be searched by manufacturing plant location, CSI division, or product type.

Products are rated in 14 environmental factors. The construction portion of the database contains information and resources for construction site recycling. The database is available on 4 diskettes from the National Park Service, or can be downloaded directly from http://www.nps.gov/dsc/dsgncnstr/.
*Contact: Mr. Bob Lopenske, Denver Service Center, 12795 W. Alameda Parkway, P.O. Box 25287, Denver, CO, 80225-0287 (303)969-5406*

*Green Developments Book and CDRom*
Over 100 case studies of green buildings around the world. Each case study includes a description of green features, cost savings and other impacts. Searchable database based on keywords, location, building type (commercial, industrial, residential, etc.) and other attributes. Contains technical briefs for various technologies as well as background information on the basics of green design. Targeted at developers, architects, and engineers. Available from Rocky Mountain Institute, *www.RMI.org*.

*Sustainable Buildings Industry Council*
Distributors of Energy 10 software. Sustainable building design assistance.
www.sbicouncil.org/

*Building Life Cycle Cost (BLCC) Software*
BLCC provides an economic analysis of proposed capital investments that are expected to reduce long-term operating costs of buildings or building systems. Up to 99 alternative designs can be evaluated simultaneously to determine which has the lowest life cycle cost. Several economic measures, including internal rate of return and payback period can be computed for each alternative. BLCC complies with ASTM standards related to building economics and NIST Handbook 135, Life Cycle Costing Manual for FEMP.
*Download:* www.eren.doe.gov *(under technical assistance/analytical software tools)*

# APPENDIX A

The forms in this appendix were compiled by the Poudre School District Green Team members (see Acknowledgements). The forms provide a consistent format for evaluating and comparing prospective environmentally preferable materials and technologies for use in Poudre School District schools. A separate form is provided for each product listed in Section 3.6.2 of this report.